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Mortimer D. Leonard

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AN ANNOTATED BIBLIOGRAPHY OF PUERTO RICAN ENTOMOLOGY

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This is an attempt to gather together all the published references to the entomology and the insects of Puerto Rico. The year 1932 is covered but several titles which were due to appear early in 1933 are included even tho two or three of the citations may be somewhat incomplete. A total of 711 titles are listed. Of these the compiler has been able to examine all but 28; those not personally examined are indicated by an asterisk. A few of the references do not mention insects from Puerto Rico but have been included in order to correct published errors. They are placed in brackets.

The task of compilation has been greater than at first expected and without the generous help of several people the results would have been much less complete. Chief of these has been Prof. C. R. Crosby of Cornell University who has supplied many references and given great assistance in the final preparation of the manuscript. Mr. A. J. Mutchler, of the American Museum of Natural History, has located many references on Coleoptera thru his wide knowledge of the literature of this group which otherwise would have been overlooked. Mr. F. W. Watson of the same institution and Dr. W. T. M. Forbes of Cornell University have both helped with titles on Lepidoptera. Dr. Wm. A. Hoffman of the School of Tropical Medicine supplied abstracts of several references and Dean Carlos A. Figueroa of the College of Agriculture loaned several rare volumes dealing with early Puerto Rican agricultural literature. Acknowledgment is due to the following librarians: Miss Ida R. Hood of the American Museum of Natural History, Mr. W. W. Ellis, of the New York State College of Agriculture at Cornell, Miss Mabel Colcord of the United States Bureau of Entomology and to Mr. J. I. Otero of the Insular Experiment Station, as well as to their associates for many courtesies and for assistance in finding many of the publications consulted. Dr. Geo. N. Wolcott at the Insular Experiment Sta-

tion at Río Piedras has been good enough to go over the manuscript and proof and has made several corrections and additions.

Anonymous. 1903. Algunos remedios contra los principales insectos que atacan el tabaco. Dept. Interior P. R., Neg. Agr. y Minas, Bol. Agr. 17, pp. 5–12. San Juan, November.

An abstract in Spanish of U. S. Farmers' Bul. 120, 32 pp., 1900 by L. O. Howard on "The principal insects affecting the tobacco plant."

1904. Some injurious garden and field insects in tropical America. U. S. Dept. Agr., Bur. Ent. Bul. **44**: p. 84.

A brief record of the damage done by several injurious insects, specimens of which were sent to the Bureau in August 1903 by O. W. Barrett of the P. R. (Mayagüez) Agr. Exp. Sta. It is chiefly of interest because these records are probably the first published notes from this Station on injurious insects. They are as follows: an aphid on squash; the leaf-beetle, *Cerotoma denticornis* Ol., infesting cowpeas; *Systena basalis* Duv. inuring sunflowers and a leafhopper, *Agallia tenella* Ball, injuring beans, cowpeas and other plants.

(Pedreira in his Bibliografía Puertorriqueña gives the authorship of this paper to L. O. Howard but there is no evidence to show that it was written by him.)

*1911. Leyes y reglamentos concernientes a la importación e inspección de plantas, enfermedades de insectos y plagas en la Isla de Puerto Rico. Junta de Comisionados de Agricultura Puerto Rico Circ. No. 1 Div. of Ent. Bur. Supplies, Printing & Transp., 7 pp., San Juan. (Published in English & Spanish)

Compiled from Act 60, Special Session Legislative Assembly 1910 and Act 45, Legislative Assembly 1911.

Anon. (pob. Wetmore. Alex.) 1913. Useful birds of Porto Rico. Porto Rico Progress **4**(13): 13, 14. San Juan, P. R.

A note on the control of the "changa" or mole cricket by herons. The article is probably by Alexander Wetmore.

1913 *b*. Destruction of mole crickets in Puerto Rico by the heron or gaulding. Agr. News, Barbados, B.W.I. **12**(298): 314.

Note on Wetmore's article on Useful Birds in Puerto Rico abstracted from the Experiment Station Record, June 1913.

1915. Law and regulations pertaining to the importation of plants to the island of Puerto Rico. Plant Quarantine Regulations. Ins. Exp. Sta. P. R. Circ. **5**: 1. April 12.

1919 *a*. Análisis de insecticidas. Rev. Agr. P. R. **3**(5): 61–62.

1919 *b*. Skunks and toads. Agr. News, Barbados, B.W.I., **18**: (458): 361.

Mention is made of the abstract on p. 362 of the Rept. Div. Ent., Ins. Exp. Sta. P. R. for 1917–18, part of which refers to the possible introduction of the toad, *Bufo marinus* L., into Puerto Rico.

1919 *c*. Entomology in Puerto Rico. Agr. News, Barbados, B. W.I. **18**, (458): 362–363.

The Ann. Rept. Div. Ent., Ins. Exp. Sta. P. R. for 1917–18 is abstracted.

1920. Estadística de los tanques de inmersión construídos en esta isla hasta junio 30, 1920. Rev. Agr. P. R. **5**(5): 38.

Data on results of use of dipping tanks for the cattle tick.

1920. Quarantine department report on inspections and interceptions, all ports and stations, for the quarter ending March 31, 1920. Qtrly. Bul. Fla. State Plant. Bd. **4**(3): 102–103.

Aspidiotus destructor intercepted 29 times on shipments from Cuba, Puerto Rico and the Isle of Pines.

1921. Report of the quarantine department from October 1, 1921, to December 31, 1921. Quart. Bul. State Plant Bd. Miss. **1**(4): 17–24., 4 figs.

Lepidosaphes beckii intercepted from Puerto Rico on orange.

1923. Pests collected from imported plants and plant products from January, 1922 to December 31, 1922, inclusive.

Aleurothrixus howardi on banana and *A. floccosus* on citrus foliage from Puerto Rico.

1924. The effect of *Melinus minutiflora* on ticks. Ann. Rept. Ins. Exp. Sta. R. P. 1923–1924, pp. 102–103.

Account of an investigation on the effect of molasses grass on the cattle tick.

1924. Report of hearing held by the Federal Horticultural Board to consider the advisability of restricting or prohibiting the entry from Puerto Rico of fruits and vegetables into the United States. Jour. Dept. Agr. P. R. **8**(1): 46. (Issued August 1925).

Reference is made to the West Indian Fruit Fly, *Anastrepha fraterculus* Wied. and to the lima bean pod-borer, *Maruca testuialis* Geyer.

*1925. Field studies and demonstrations in malaria control. Rockefeller Found. 11th. Ann. Rept. Intern. Health Bd. 1924, pp. 73–84, New York, January. (Abs. in Rev. Appl. Ent. B **14**: 51–52).

Conditions in Puerto Rico reported on, including the comparative abundance of the 3 species of Anopheles present.

1926. Studies of the malaria problem in Puerto Rico. P. R. Health Rev. **2**(5) : 22–28. (Abs. in Pub. Health Repts. **42** (13) : 897, Washington, D. C., April 1, 1927).

Influence of vegetation and small fish on mosquito abundance.

1927 *a*. Se introducen parásitos del taladrador de la caña de azúcar en Puerto Rico. Rev. Agr. P. R. **19**(1) : 33. July.

A Spanish translation of a review in Facts About Sugar of an article by L. A. Catoni in Jour. Dept. Agr. P. R. **10**:252–254, 1910 dealing with parasite introduction into Puerto Rico.

1927 *b*. Insect pests of sugar cane (including utilization of parasites). Proc. 2nd. Conf. Internat. Soc. Sugar Cane Technol., pp. 57–62, Havana, Cuba Sugar Club.

A record of a preliminary meeting of the committee for the section on insect pests of sugar cane at which there was a general discussion of borers, mostly *Diatraea saccharalis* Fab.; losses and the factors causing them for various countries are discussed, among which it is stated that in Puerto Rico the infestation is inversely proportional to rainfall.

1927 *c*. Studies of the malaria problem in Puerto Rico. P. R. Health Rev. **2**(8) : 25–32.

Malaria investigations in 1924 and 1925 which include notes on *Anopheles grabhami* Theo. and *A. vestipennis* D. & K.

*1927 *d*. Studies in the malaria problem in Puerto Rico. P. R. Health Rev. **2**(10) : 27–32 and **2**(12) : 25–31. (Abs. in Rev. Appl. Ent. B 16 p. 64 and in U. S. Pub. Health Rep. **42**(39) : 2395 and **42**(51) : 3142).

Notes on the comparative abundance, numerical and seasonal, and biting and breeding habits of the 3 species of *Anopheles* present.

1928 *a*. Algunas consideraciones sobre la industria apícola. Rev. Agr. P. R. **21**(2) : 56, 82.

Notes on beekeeping in Puerto Rico.

1928 *b*. Sugestiones a los principiantes en apicultura. Rev. Agr. P. R. **21**(4) : 153, October.

Brief suggestions on beekeeping.

1928 *c*. Report of bureau of malaria control 1926–27. P. R. Rev. Pub. Health & Trop. Med. **3**(7) : 279–286; **3**(9) : 376–385. (Abstracted in Rev. Appl. Ent. 16: 239 and 209 respectively and the former also in U. S. Pub. Health Repts. 43(30) : 1992–1993, 1928).

Notes on the breeding and habits of the 3 species of *Anopheles* present.

*1929. Report of bureau of malaria control 1926–27. Rept. Comm. Health P. R. 1926–27, pp. 62–95. (Abs. in Rev. Appl. Ent. B **17** : 218).

Drainage problems discussed; tests of durability of screening materials; Paris green at weekly intervals for *Anopheles albimanus* too infrequent.

1931. El gorgojo del ñame del guineo. Bol. Agr. (P. R. Dept. Agr.) **1**(4) : 3–4.

Brief report on the results of a survey of 3 districts to determine the amount of infestation by the banana root weevil.

1932. Florida beetle put to test, curbing P. R. citrus pest. The Produce News, June 11, New York, front page.

Brief note on original shipment of Australian lady beetles, *Rodolia cardinalis*, to Puerto Rico by the Florida State Plant Board for the control of *Icerya purchasi* on citrus.

* **Abad, José Ramón.** 1885. Puerto Rico en la exposición de Ponce en 1882. Memoria redactada de orden de la Junta Directiva de la misma. 351 pp. El Comercio, Ponce, P. R. (Reference from Colón, E. D. 1930).

Suggestions for the proper care of bees are given and it is stated that some of the people are engaged in beekeeping.

Abbad y Lasierra, Fray Iñigo. 1788. Historia geográfica, civil y natural de la isla de San Juan Bautista de Puerto Rico, 508 pp. + X, Madrid. (Nueva Edición, anotada en la parte histórica y continuada en la estadística y económica por José Julián de Acosta y Calbo, Puerto Rico, 1866).

Chapter 35 deals briefly with the natural history of the Island; on pp. 457–462 is probably the earliest general account of the more important groups of insects present with special reference to those annoying to man and animals; no scientific names are given.

Aldrich, J. M. 1905. A catalogue of North American Diptera. Smithsonian Miscl. Coll., part of Vol. **46**, (1444), 680 pp.

Records all West Indian species described thru 1903, including many from Puerto Rico.

Alexander, C. P. 1912. A peculiar new crane fly from Puerto Rico. Psyche 19: 63–66, 1 pl.

Megistomastix portoricensis as a new genus and species.

1913. A synopsis of part of the neo-tropical crane-flies of the subfamily Limnobiinae. Proc. U. S. Nat. Mus. Vol. **44** (1966): 501.

Mongoma niveitarsus as a new species from Puerto Rico.

1914. A revision of the American species of Tanypremna Osten Sacken and Megistocera Wiedemann. (Tipulidae, Diptera). Jour. N. Y. Ent. Soc. **22**(3): 216–217.

Megistocera longipennis Macq. listed from Puerto Rico on the authority of Roeder.

1932. The craneflies of Puerto Rico. Jour. Dept. Agr. P. R. **16**(4): 347–387.

Ashmead, W. H. 1900. Report on the aculeate Hymenoptera of the islands St. Vincent and Grenada, with additions to the parasitic Hymenoptera, and a list of the described species of the West Indes. Trans. Ent. Soc. London for 1900 Pt. 2 (July), pp. 207–368.

Lists many species from Puerto Rico.

Aubé, Ch. 1844. Revision de la famille des Pselaphiens. Ann. Soc. Ent. France, 2 Ser., Vol. **2**, p. 120.

Reichenbachia usera listed from Puerto Rico (as Bryaxis).

Aurivillius, Chr., **Wagner, H.** and **Strand, E.** 1911 to date. Lepidopterorum Catalogus. Berlin.

Forty odd Fascicles have appeared to date by various authors in which many species are listed as specifically occurring in Puerto Rico.

Bagué, Jaime. 1918. Extirpación de la garrapata. Rev. Agr. P. R. **1**(1 and 2): 81–85. (Also as Est. Exp. Ins. P. R. Circ. **18**, 12 pp., 1919.)

Notes on the campaign against the cattle tick.

1920. Annual report of the veterinary inspector. Ann. Rept. Ins. Exp. Sta. 1919–20, pp. 95–101.

Report on dipping vats for cattle tick eradication.

1921. La piroplasmosis o fiebre tejas. Ins. Exp. Sta. P. R. Circ. **45**, 5 pp.

Only reliable method for control of Texas fever in Puerto Rico is extermination of the cattle tick; the value of arsenical dips is discussed.

1929. ¿Garrapata o ganado? Sección española del Boletín de la Unión Panamericana, April. (From Pedreira p. 208). (Also in the Rev. Agr. P. R. **22**(10): 139, April, 8 figs.)

A general account of the cattle tick problem with special reference to the situation in Puerto Rico and methods adopted for handling it there.

* **Baldorioty de Castro, Román.** 1865. Memoria descriptiva de la cuarta feria y exposición pública de la agricultura, la industria y las bellas artes de la isla de Puerto Rico. By the Secretary of the Commission. San Juan, P. R. (Reference from Colón, E. D. 1930, p. 21, ref. no. 41, and p. 156).

At the fourth public exposition held in the Island in 1865 Don Alejo Fernández of Aguadilla exhibited wax and honey as the products of 250 hives of bees.

Ballou, H. A. 1913. Root borers and other grubs in West Indian soils. Imp. Dept. Agr. W. I., Pamphlet Ser. No. 73, 38 pp.

Puerto Rican references: brief notes on *Lachnosterna sp.*, p. 17: *Diaprepes spengleri* listed as injurious, p. 36; *Lachnosterna* listed as injurious, p. 37; *Strategus titanus* listed as injurious, p. 38.

1915. Notes on Puerto Rico insects. Agr. News, Barbados, B. W. I., August 28, 14, (348), p. 282.

Abstracts are given of P. R. Bd. Comm. Agr. Circ. 6 by Crossman and Wolcott on the changa and of U. S. D. A. Bul. 192 by T. H. Jones on Vegetable Insects in Puerto Rico, both of which see.

1916. Dangerous hard-backs. Agr. News, Barbados, 15 (359): 42–43, 5 figs.

The injury to sugar cane roots in Puerto Rico by *Strataegus titanus* is referred to.

Baly, J. S. 1886. Descriptions of uncharacterized species of Diabrotica. Trans. Ent. Soc. London, Pt. 4, pp. 443–444.

D. graminea described as a new species from Puerto Rico.

Banks, Nathan. 1901. Some spiders and other Arachnida from Puerto Rico. Proc. U. S. Nat. Mus. **24**: 217–227, 1 pl.

Report on a collection made by August Busck; 49 species of spiders and 5 other arachnids treated, of which 4 species of spiders are described as new.

1917. New mites, mostly economic (Arach., Acar.). Ent. News **28**(5): 194, pl. 14, fig. 5 and pl. 15, fig. 13.

Tetranychus antillarum described as a new species from leaves of *Leonotis nepetafolia* and *Asclepias curassivica* from Puerto Rico.

1919. Antillean Isoptera. Bul. Mus. Comp. Zool. **62**(10): 484–489.

Nasutitermes creolina from Vieques Id. and P. R. and *N. discolor* from Culebra Id. and El Yunque, both as new species (paratypes) and *N. morio* listed from Puerto Rico.

Banks, N. and **Snyder, T. E.** 1920. A revision of the nearctic termites. U. S. N. Mus. Bul. **108**, p. 82.

Nasutitermes costaricensis Holmg. listed from Puerto Rico.

Barber, H. G. 1923. A preliminary report on the Hemiptera Heteroptera of Puerto Rico collected by the American Museum of Natural History. Am. Mus. Novitates No. 75, 13 pp.

Several new species described.

Barber, H. G. and **Bruner, S. C.** 1932. The Cydnidae and Pentatomidae of Cuba. Jour. Dept. Agr. Puerto Rico, **16**(3): 231–284, pl. 25, fig. 1.

Geocnethus reversus new species, type and paratypes from Mayagüez, Río Piedras and Isabela, P. R.

Barrett, O. W. 1902. The changa or mole cricket. (*Scapteriscus didactylus* Latr.) in Puerto Rico. P. R. Agr. Exp. Sta. (Mayagüez) Bul. **2**, 19 pp., 1 fig. (Also a Spanish edition).

1904. Control of the brown ant (*Solenopsis geminata* Fab.) in orange orchards. (Also a Spanish edition). P. R. Agr. Exp. Sta. Circ. **4**, 3 pp.

Brief account of life-history, injuries and remedial measures.

1906. Report of the entomologist and botanist. Investigations in entomology and plant pathology. P. R. Agr. Exp. Sta. (Mayagüez), Rept. for 1905, pp. 22–23.

First record of *Zagrammosoma multilineata* Ashm. parasitic on the coffee leaf-miner; cotton leaf worm parasitized by *Chalcis annulata* Fab.

1928. The tropical crops. MacMillan Co., New York, 445 pp.

Many references thruout to the principal injurious insects of Puerto Rico.

Barrow, E. H. 1924. White grubs, *Lachnosterna* sp., and larvae of the weevil root-borer, *Diaprepes spengleri* L., attacking sugar cane in the Guánica district of Puerto Rico and methods for controlling them. Jour. Dept. Agr. P. R. **8**(2) : 22–26.

Bastón, J. 1928. Produciendo mosquitos. Rev. Agr. P. R. **20**(5) : 239 and 245.

Notes on breeding and control of mosquitoes.

Berger, E. W. 1921. Natural enemies of scale insects and whiteflies in Florida. Qrtly. Bul. Fla. State Plant Bd. **5**(3) : 147–148, fig. 18.

Eucalymnatus tesselatus is recorded as being found infested by the fungus, *Aschersonia cubensis*, in material received from Puerto Rico.

Bigot, J. 1877. Dipteres nouveaux ou peu connus. IX. Ann. Soc. Ent. France, Ser. 5, Vol. **7**, p. 46.

Lucillia semiviolacea as a new species from Puerto Rico (as *Somomyia*).

Bishoff, Augusto. 1918. Extirpación de la hormiguilla. Rev. Agr. P. R. **1**(1 and 2) : 38–42.

Suggestions for the control of ants.

Blake, Doris H. 1928. Notes on some West Indian Chrysomelidae. Bul. Brooklyn Ent. Soc. **23** : 93–98.

Dysonychia spilotrachela as a new species from Haiti and Puerto Rico.

Boheman, C. H. 1865. Monographia Cassididarum **3** : 333–334.
Coptocycla glaucina as a new species from Puerto Rico.

* **Bovel, J. R.** 1918. Report of the Department of Agriculture, Barbados, for 1916–1917, 62 pp. (Abs. in Rev. Appl. Ent. **6** : 393).

Stated that related species of *Diaprepes* and *Phytalus*, so trouble-

some to cane in Barbados, are on the increase in Puerto Rico and very injurious there.

* **Bovel, J. R.** and **d'Albuquerque, J. P.** 1917. Report on the sugar-cane experiments for the season 1915–1917. Dept. Agr. Barbados, 79 pp, 56 tables. (Abs. in Rev. Appl. Ent **6**: 58.)

Varietal and manure experiments inconclusive because of severe injury by *Diaprepes* and *Phytalus.* Stated that in Puerto Rico the the cost for handpicking for their control in one small district was about $6,000 and yet they increased.

***Box, H. E.** 1924. Report upon a trip to Puerto Rico, April–July, 1924, 22 pp., Berbice, British Guiana, S. Davson & Co., Ltd., November (Abs. in Rev. Appl. Ent. 13: 86).

Record of a trip made to study the Tachinid, *Lixophaga diatraeae* Towns., and to transport it into British Guiana; notes on the principal sugar cane insects of Puerto Rico and their parasites, especially *L. diatraeae,* including some observations on its distribution and incidence there.

1925. Porto Rican cane grubs and their natural enemies, with suggestions for the control of Lamellicorn larvae by means of wasp parasites (Scoliidae). Jour. Dept. Agr. P. R. **9**(4): 291–356.

*1927 *a.* Notas sobre dos insectos perjudiciales a las matas de café en Venezuela, 19 pp., 10 figs., 11 refs., Caracas, Cámara de Comercio, March. (Abs. in Rev. Appl. Ent. **15**: 324).

In discussing the green scale, *Coccus viridis* Green, in Venezuela it is stated that *Azya orbigera* Muls., a well-known Coccinellid predaceous on various Coccids in South America, has been sent to Puerto Rico for possible establishment.

1927 *b.* Eleventh report upon entomological work, 24 pp., typescript. Central Aguirre, P. R., Central Aguirre Sugar Co., April 9th. (See abs. in Rev. Appl. Ent. **15**: 412–414.)

A detailed account of a trip to South America during January–April, 1927 to make further introductions of Braconid parasites of *Diatraea* and Scoliid parasites of cane grubs into Puerto Rico. Notes on *Diatraea* and its parasites in Venezuela are given together with notes on conditions on Puerto Rico that affect their introduction and establishment. (For another account of this trip see Catoni 1927.)

*1927 *c.* The moth borer problem in Barbados. A discussion and a recommendation. Dept. Sci. and Agr. Barbados, 5 pp.,

multigraph, Barbados, March 25. (Abs. in Rev. Appl. Ent. **15**: 430.)

Refers to the occurence of *Lixophaga diatraeae* in Puerto Rico as a parasite of *Diatraea saccharalis* and states that this parasite has apparently reached the limit of its effectiveness there. It is suggested that its introduction should be attempted from Puerto Rico into Barbados.

1928 *a*. Observations upon *Lixophaga diatraeae* Townsend, a Tachinid parasite of *Diatraea saccharalis* Fabr. in Puerto Rico. Bul. Ent. Res. **19**: 1–6, 1 fig.

1928 *b*. The introduction of Braconid parasites of *Diatraea saccharalis* Fabr. into certain of the West Indian Islands. Bul. Ent. Res. **8**(4): 365–370, 1 pl., 2 figs.

A further detailed account of the collection, rearing, shipment and introduction of Braconid parasites of *Diatraea saccharalis* F. into Puerto Rico as well as into Barbados, Antigua and St. Kitts. Stated that *Microdus diatraeae* Turner has already become established on the South Coast of P. R.; present paper deals mostly with *Ipobracon grenadensis* Ashm.

1931. The Crambine genera *Diatraea* and *Xanthopherne* (Lep., Pyral.). Bul. Ent. Res. **22**: 1–50, 5 pls.

Diatraea saccharalis Fab., pp. 22–26, synonymy, description and distribution, including Puerto Rico in its known range.

Bradt, Schuyler. 1932 *a*. Notes on Puerto Rican blackflies. P. R. Jour. Pub. Health & Trop. Med. **8**(1): 69–81 (2–11), 5 figs.

Original observations on the habits and development of *Simulium quadrivittatum* Loew with descriptions of its stages; brief notes also on *S. haematopotum* Lw. and *S. minusculum* Lutz.

1932 *b*. Nota sobre la mosca negra en Puerto Rico. P. R. Jour. Publ. Health & Trop. Med. **8**(1): included in 69–81 (pp. 12–14 of reprint).

This is an abstract in Spanish of the preceding.

Brau, Salvador. 1930. La colonización de Puerto Rico desde el descubrimiento de la isla hasta la reversión a la corona española de los privilegios de Colón. San Juan, P. R., pp. 296–298.

Brief references to great injury to bananas by ants in the early part of the 16th century; also to oranges and "cañafístula"; it is stated that the ants were so bad in houses that the residents of Caparra advanced this as one of the principal arguments for wanting

to move their city to the "Isleta"—the present site of the city of San Juan.

Brau Zuzuarregui, Mario. 1922. Pájaros útiles y perjudiciales a la agricultura. Rev. Agr. P. R. **8**(5&6): 13–18, 27–32; **9**(2&3): 25–31, 17–20, 11 figs.

Brief account of the various insectivorous birds of Puerto Rico that should be protected, including several specifically mentioned as important enemies of *Scapteriscus vicinus, Diatraea saccharalis, Heliothis obsoleta, Laphygma frugiperda* and of *Phyllophaga* (*Lachnosterna*) spp.

1928. Divagaciones entomológicas. Rev. Agr. P. R. **21**(6): 211 and 239–240, 1 fig.

Brenner, Henry. 1916. Puerto Rico and its beekeepers. Am. Bee Jour. **56**: 380–381, 2 figs.

1918. Puerto Rican beekeeping. Am. Bee Jour. **58**: 51–52, 4 figs.

Brief general account.

Britton, N. L. 1930. Scientific survey of Puerto Rico and the Virgin Islands. Jour. N. Y. Bot. Gard. **31**: 167.

Brief note on entomological progress during winter and spring of 1929–30.

1931. Recent scientific observations in Porto Rico. Jour. N. Y. Bot. Gard. **32**: 192.

Brief note on the present status of the entomological part of the Sci. Surv. of P. R. and the Vir. Ids. and progress during winter and spring of 1930–31.

Brown, F. Martin. 1929. A revision of the genus *Phoebis* (Lepidoptera). Am. Mus. Novitates No. 368, pp. 8–9, 20.

P. eubule sennae female form *sennalba* described as a new form from Puerto Rico (a paratype).

1931. A revision of the genus *Aphrissa*. Am. Mus. Novitates No. 454, p. 5, Feb. 9.

A. godartiana Swainson mentioned as occurring in Puerto Rico.

Bryant, G. E. 1924. New species of phytophaga (Coleopt.) Ann. and Mag. Nat. Hist. Ser. 9, **41**: 244–252.

Galerucella wolcotti described as a new species from Puerto Rico.

Brunner von Wattenwyl, C. 1865. Nouveau systeme des Blattaires, p. 63. (Vienna).

Anaplecta dorsalis as a new species from Puerto Rico.

1895. Monographie der Pseudophylliden. Wien. p. 233, pl. IX, fig. 101.

Polyancistrus serrulatus P. de B. (Locustidae) listed from Puerto Rico.

Brunner von Wattenwyl, C. and **Redtenbacher, Jos.** 1908. Die Insektenfamilie der Phasmiden, pp. 357, 435.

Dyme krugiana from the main island, *Lamponinus bocki* from Mona Island and *Diapherodes longiscapha* from the main island, all as new species.

Burmeister, G. 1839. Handbuch der Entomologie, **2**: 753. (Berlin).

Psalis americana var. *gagathina* as a new variety from Puerto Rico (=*P. buscki* Rehn) Forficulidae.

Busck, August. 1900. Notes on a brief trip to Puerto Rico in January and February, 1889, including a "List of Coccidae collected by Mr. A. Busck in Puerto Rico, 1889" by T. Pergande and T. D. A. Cockerell. U. S. Bur. Ent. Bul. **22** (N. S.), pp. 88–93.

Butterweck, O. C. 1902. El cultivo del tabaco. Dept. Int. P. R., Neg. Agr. y Minas, Bol. Agr. 2 pp. 18–19.

A Spanish translation of U. S. Farmers' Bul. 82 "The Culture of tobacco," 1898, which contains brief general directions for the control of the more important insect pests.

del Campo, Alberto. 1923. La industria de la seda. Rev. Agr. P. R. **11**(1): 17.

Camuñas, Manuel. 1919. Report of the Commissioner of Agriculture and Labor. 19th Ann. Rept. Gov. P. R. to Secy. War, Washington, D. C., 1919, Appendix IX, pp. 685–707.

Notes are included on citrus insects and their control and on experiments in insect transmission of sugar cane mosaic.

1921. A los agricultores de Puerto Rico y especialmente a los cosecheros de algodón. Rev. Agr. P. R. **7**(3): 5–7.

A note regarding pink bollworm control.

Carnes, E. K. 1912. Insectary division, report for the month of May 1912. Cal. State Comm. Hort. Bul. **1**(8): 398.

Reports *Chrysomphalus aonidum* L. and *Lepidosaphes beckii* received from C. W. Hooker from Puerto Rico from which *Aspidiotiphagus citrinus* issued in considerable numbers but in a second shipment very few *citrinus* issued.

Carrión, Arturo L. *1927. Preliminary report on a rat and flea survey of the City of San Juan, Porto Rico. P. R. Rev. Pub. Health & Trop. Med. **3**: 131–145. (Reference and abstract from Wm. A. Hoffman).

During the first year of Survey 360 live rats were trapped on 53.6% of which fleas were found; practically all were *Xenopsylla cheopis* with an occasional *Ctenocephalus* and a few *Echidnophaga gallinacea;* "cheopis index" for the year quite high—7.05.

*1928. Preliminary report on a rat-flea survey of the City of San Juan, Puerto Rico. Second paper. P. R. Rev. Pub. Health & Trop. Med. **4**(2): 84–92, 7 charts. (Abs. in Rev. Appl. Ent. **17**: 26).

Covers period of July 1927 thru June 1928; 53% of rats captured had fleas; of 2,C00 fleas which were determined 99.5% were *Xenopsylla cheopis* Roths., the remainder being *E. gallinacea, Ct. canis or felis, Pulex irritans* and *Leptopsylla segnis* Schonh. (*musculi* Dug.); the flea index and cheopis index for the year were practically the same—6.6. *Mus alexandrinus* revealed the highest infestation for the year.

*1929. Third report on a rat-flea survey of the City of San Juan, Puerto Rico. P. R. Jour. Pub. Health & Trop. Med. **5**(2): 158–166, 7 charts. (Abs. in Rev. Appl. Ent. B **18**: 248; also by same title in Pub. Health Rept. **45**(27): 1515–1520, 7 charts, Washington, D. C., July 4.)

Xenopsylla cheopis Roths. (over 500 per cent of total number caught), *Echidnophaga gallinacea* Westw. *Ctenocephalus canis* Curt. or *C. felis* Bch. and *Pulex irritans* L. found on 60 per cent of rats captured.

*1932. Final report on a rat-flea survey of San Juan, Porto Rico. Publ. Health Repts. **47**: 193–201, Washington, D. C. (Reference and abstract received from Dr. Wm. A. Hoffman).

This survey includes 3 consecutive years of work, during which period a total of 1,005 live rats were captured; of these 72 per cent were classed as *Rattus norvegicus* and *R. alexandrinus* in proportions of 13 and 15 per cent respectively. Fleas were obtained from almost

57 per cent of the rats, the total number for the 3 years being 7,145 or an index of 7.1 fleas per rat. Five species of fleas were encountered but of these *Xenopsylla cheopis* composed 98.5 per cent of the total catch. The concentration of rats is heaviest at the water-front and in the residential sections while the flea index is highest at the docks (almost 14 fleas per rat) and in the commercial district (almost 6 fleas per rat).

Catoni, L. A. 1920 *a.* Plagas de insectos que atacan a los árboles del género citro en Puerto Rico y cómo combatirlos. Rev. Agr. P. R. 5(4): 35–39.

A brief popular account of the more important insects injurious to citrus in Puerto Rico and methods of control.

1921 *b.* Dos plagas de algodón que no queremos en Puerto Rico. Est. Exp. Ins. P. R. Circ. **41**, 9 pp.

Refers to the pink boll worm and the boll weevil of cotton not found up to that time in Puerto Rico.

1921 *c.* El gas hidrociánico como agente fumigante. Rev. Agr. P. R. **5**(7): 27–36.

Directions for the preparation and use of hydrocyanic acid gas.

1921 *d.* Insectos que atacan al hombre. Rev. Agr. P. R. **6**(2): 47–49.

Brief popular account of the more important insects annoying to man in Puerto Rico.

1921 *e.* Insectos que atacan al algodón. Rev. Agr. P. R. **6**(3): 25–31.

Brief popular account of the more important cotton insects in Puerto Rico.

1921 *f.* Plagas de insectos que atacan la palma de coco. Rev. Agr. P. R. **7**(3): 21–25.

Brief popular account of the more important insects attacking the coconut in Puerto Rico.

1921 *g.* Plagas de insectos que atacan la planta del tabaco. Rev. Agr. P. R. **7**(5): 45–50.

Brief account of the more important tobacco insects in Puerto Rico.

1921 *h.* A los cosecheros de algodón en Puerto Rico. Rev. Agr. P. R. **7**(6): 25–26.

Brief notes of information for the cotton growers concerning the

presence of the pink bollworm in Puerto Rico and an interception of the boll-weevil.

1921 *i*. Plant inspection and quarantine report. Ins. Exp. Sta. P. R. Bul. **27**, 23 pp. (also a Spanish edition 25 pp.).

1922 *a*. Informe de las actividades de la campaña de eradicación del gusano rosado en Puerto Rico llevada a cabo por el departamento de agricultura y trabajo. Rev. Agr. P. R. **8** (4) : 15–22.

Notes on a clean-up campaign against the pink bollworm.

1922 *b*. Plagas de insectos que atacan a las plantaciones de batatas. Rev. Agr. P. R. **9**(3) : 25–28.

Brief account of the more important sweet-potato insects in Puerto Rico and their control.

1922 *c*. Medidas para combatir las plagas de insectos. Rev. Agr. P. R. **9**(4) : 33–36.

Brief directions for the preparation and use of a few of the more important insecticides.

1922 *d*. Situación existente de varias plagas de insectos de los Estados Unidos. Rev. Agr. **9**(4) : 43–45.

1923 *a*. Aparatos apropriados para combatir las plagas de insectos. Rev. Agr. P. R. **10**(1) : 27–29.

Suggestions for various types of spray machines for use against injurious insects.

1923 *b*. Insectos que atacan a los animales domésticos. Rev. Agr. P. R. **10**(3) : 35–39.

Brief account of the more important insects attacking domestic animals with suggestions for their control.

1923 *c*. Gorgojos que atacan a las habichuelas y guisantes. Rev. Agr. P. R. **10**(3) : 49–51.

Brief account of pea and bean weevils with suggestions for their control.

1923 *d*. Las chinches harinosas y los métodos de combatirlas. Rev. Agr. P. R. **10**(5) : 35–37.

Brief account of mealybugs affecting citrus, cane and other plants in the Island and suggestions for their control.

1923 *e*. El picudo del aguacate. Rev. Agr. P. R. **11**(6) : 55–56.

Brief account of the avocado weevil, *Heilipus lauri*, in Puerto Rico.

1924. Informe del servicio de inspección y cuarentena de plantas (1922–1923). Dept. Agr. P. R. 23 pp.

1927. Informe del viaje verificado a Venezuela con objeto de introducir parásitos para combatir el taladrador de la caña de azúcar en Puerto Rico. Rev. Agr. P. R. **18**(5): 252–254.

Notes on a trip to Venezuela with H. E. Box to collect and introduce into Puerto Rico parasites of the sugar cane borer.

Caudell, A. N. 1905. A new roach from Puerto Rico. Can. Ent. **37**(6): 237.

Ischnoptera adusta, type a male from Arroyo, Feb. 1889 (A. Busck).

1907. On some Forficulidae of the United States and the West Indies. Jour. N. Y. Ent. Soc. **15**(3): 168.

Anisolabis ornata as a new species from Puerto Rico.

1912. Notes on the Mantid genus *Gonatista* Sauss. Psyche **19** (5): 160–162.

Gonatista reticulata Thunberg mentioned as occurring in Puerto Rico.

Chamberlin, R. V. 1917. New spiders of the family Aviculariidae. Bul. Mus. Comp. Zool. **61**(3): 39–40, pl. 2, fig. 7.

Cyrtopholis portoricae described as a new species from Puerto Rico.

1922. Notes on West Indian millipedes. Proc. U. S. Nat. Mus. **61**, Art. 10, (2431): 1–15.

Glomeridesmus concolor Chamb., El Yunque 1900 and *Prostemmiulus compressus* Karsch, El Yunque and Adjuntas, 1900, p. 1; *Epinannolene trinidadensis* Chamb., San Juan, 1899 and *Orthoporus sculpturatus* Karsch, Lares, 1899, p. 3; *Rhinocricus arboreus krugii* Karsch, El Yunque, 1900 and *R. arboreus gundlachii* Karsch, El Yunque, Pueblo Viejo, Manatí and Vega Baja, p. 9; *Microspirobolus richmondi* new species, El Yunque, 2,800 ft., 1900, p. 13; *Ricodesmus stejnegeri* new genus and species, El Yunque, La Muda and Lares, p. 15.

Champion, G. C. 1898. A list of the clavicorn Coleoptera of St. Vincent, Grenada, and the Grenadines. Trans. Ent. Soc. London for 1898, p. 401.

Pycnomerus exaratus Chev. listed as occurring in Puerto Rico.

Chapin, E. A. 1930. *Canthonella*, a new genus of Scarabeidae (Coleoptera). Am. Mus. Novitates No. 409, March 18, 2 pp.

C. parva as a new species from Puerto Rico.

1932. Revision of the pleurostict Scarabeidae of Cuba and Isle of Pines. II. Rutelinae, Dynastinae, and Cetoniinae. Ann. Ent. Soc. Am. **25**(2): 282–314, 3 pls.

Dyscinetus picipes Burm., pp. 293–294, described; the type locality stated as Puerto Rico; it is said to be common in this Island.

Chapuis, F. 1866. Monograph des Platypides. Mem. Soc. Royal des Sci. Liége, 20: 181–182.

Platypus schaumi as a new species from Puerto Rico.

Chardon, Carlos E. 1923. Report of the special pathologist. Ann. Rept. Ins. Exp. Sta. P. R. for 1921–22, pp. 61–68. (Also a Spanish edition, pp. 67–74, 1922.)

A report on a study of the factors affecting the spread in the field of sugar cane mosaic, including periodic observations on all possible insect vectors made in 40 observation fields.

1924. Stahl, Agustín. Rev. Agr. P. R. **12**(2): 68–84.

A biographical sketch of the outstanding naturalist of Puerto Rico in which reference is made to his contributions to the knowledge of the insect fauna of the Island.

Chardon, C. E. and **Veve, R. A.** 1923. The transmission of sugar cane mosaic by *Aphis maidis* under field conditions in Puerto Rico. Phytopathology **13**(1): 24–29, 1 fig.

Chevrolat, L. A. A. 1864. Coléopteres de l'isle de Cuba. Notes synonymies et descriptions d'especes nouvelles. Cinquieme mémoire. Ann. Soc. Ent. France Ser. 4, Vol. 4, p. 414.

Psammodius gracilis as a new species from Cuba, Puerto Rico and Guadeloupe.

Chevrolat, M. Aug. 1876. Donne la description de Curculionites provenant des captures de M. le docteur Gundlach á l'île Porto-Rico. Ann. Soc. Ent. France, Ser. 5, Vol. **6**, Bulletin, pp. (227–229) CCXXVII–CCXXVIX.

Pachneus roseipes, *Lachnopus trilineatus*, *Anchonus angulicollis*, *Attelabus* (*Euscelis*) *sexmaculatus*, and *Anthonomus dentipennis* as new species from Puerto Rico and 5 other species also listed as occurring there.

1877. Descriptions of new species of Heteromera from the island of Puerto Rico collected by Dr. Gundlach. Bul. Soc. Ent. France, Ser. 5, Vol. **7**: 8–10.

Diastolinus fuscicornis, *Notoxus bipunctatus*, *Emenadia melanop-*

tera, *Epicauta annulicornis*, *E. obscuripennis* and *Oxacis geniculata* as new species from Puerto Rico.

Notoxus dentipennis Chev. cited by Gundlach and copied by Wolcott on page 85 of this "List" is probably in error for *N. bipunctatus* Chev. since there seems to be no reference to a species of this name other than by the two authors mentioned above.

Chittenden, F. H. 1919. The rice moth. U. S. Dept. Agr. Bul. 783, 15 pp.

Puerto Rican records of *Corcyra cephalonica* Staint, in rice sacks.

Cintrón, M., and **Marques, N.** 1926. Resultados obtenidos en la demostración número 91 sobre "represión del gorgojo del maíz". Rev. Agr. P. R. **17**: 18, November.

Results of a demonstration in the control of the corn weevil.

Clark, B. Preston. 1919. Some undescribed Sphingidae. Proc. New Eng. Zool. Club. **6**: 100–101, pl. X, fig. 1.

Protoparce brontes Drury var. *smythi* as a new subspecies from Río Piedras, P. R.

1922. Twenty five new Sphingidae. Proc. New Eng. Zool. Club, **8**: 8–9.

Isognathus rimosa Grote var. *wolcotti* as a new variety from Puerto Rico.

Clark, Hamlet. 1860. Catalogue of Halticidae in the collection of the British Museum. (London), p. 131.

Aedmon sericellum as a new species from Puerto Rico.

Cockerell, T. D. A. 1895. Miscellaneous notes on Coccidae. Can. Ent. **27** (9): 253-261.

Aspidiotus destructor Sign. listed from Puerto on cocoanut palm as the first Coccid record for the Island.

1910. Some bees of the genus Augochlora from the West Indies. Proc. U. S. Nat. Mus. Vol. **37**, (1717): 493.

Augochlora buschii as a new species from Puerto Rico.

1919. Bees in the collection of the United States National Museum. -3. Proc. U. S. Nat. Mus. Vol. **55**, (2264) p. 209.

Agapostemon radiatus portoricensis as a new subspecies from Puerto Rico.

Coll y Toste, Cayetano. 1914. A memoria in the Boletín Histórico de Puerto Rico 1: 303.

In this memoria prepared by Dr. Coll y Toste he copies the Cédula

de Gracia (Decree of Grace) of August 10, 1815, Article 31 of which provides that the Governor of Puerto Rico establish a Quarantine against the introduction of ants and appointed two qualified persons to examine all incoming baggage, passengers and ships. This is probably the first quarantine in Puerto Rico against an injurious insect. (Leonard 1932 f. gives a translation of this decree in full).

Colón, E. D. 1919 *a*. El sulfato de amoníaco como insecticida. Est. Exp. Ins. P. R. Circ. **15**, 6 pp.

Notes on the possibility of using sulfate of amonia in Puerto Rico for the control of white grubs in sugar cane and at the same time as a fertilizer.

1919 *b*. Report of the director—Division of entomology, review of its work. Ann. Rep. Ins. Exp. Sta. P. R. for July 1, 1917 to June 30, 1918, pp. 29–59.

An excellent review, presented in considerable detail, of the work of Division of Entomology from its establishment up to that time.

1930. Datos sobre la historia de la agricultura de Puerto Rico antes de 1898, viii + 302 pp., Cantero Fernández y Cía., San Juan, P. R.

On pp. 155–159 are notes regarding the introduction of bees into the Island and on apiculture based mostly on the writings of Ledru and of J. R. Abad. On pp. 227–232 brief reference is made to insecticides recommended and to several of the more important injurious insects; these are mostly on the authority of López Tuero and Herrera, which see. On p. 276 are one or two brief quotations from J. R. Abad on early (1854) attempts to produce silk in Puerto Rico.

1931. Informe anual del comisionado de agricultura y comercio correspondiente al año fiscal 1930–1931. (Puerto Rico), pp. 18–19, 95–109, 122–124.

A brief review of entomological activies of the Insular Experiment Station and the Plant Quarantine Section during the period covered.

Colón, Isidoro A. 1919 *a*. Insecticidas y fungicidas. Est. Exp. Ins. P. R. Bol. **20**: 1–23.

Chemical notes on some of the more common insecticides and a table of analyses of samples examined from different sources in Puerto Rico.

Cook, Mel. T. and **Dozier, H. L.** 1925. Spraying citrus fruits in Porto Rico. Ins. Exp. Sta. P. R. Circ. **88**: 1–23.

Coquillett, D. W. 1899. New genera and species of Nycteribidae and Hippoboscidae. Can. Ent. **31**: 333–336.

Aspdioptera busckii as a new species and *Pterellipsis araenee* as a new genus and species from Puerto Rico.

1900. Report on a collection of dipterous insects from Porto Rico. Proc. U. S. Nat. Mus. Vol. **22**(1198) : 249–270.

117 species in 79 genera are mentioned, of which 16 species and 3 genera are described as new.

1902. New acalyptrate Diptera from North America. Jour. N. Y. Ent. Soc. **10**(4) : 190.

Agromyza viridula as a new species from Puerto Rico.

Cotton, R. T. 1917 *a*. The eggplant lace-bug in Puerto Rico. *Corythaica monacha* Stal. Jour. Dept. Agr. P. R. **1**(3) : 170–173.

Complete account of life-history, description of stages, natural enemies and control.

1917 *b*. Life history of *Haltica jamaicensis* Fabr. Jour. Dept. Agr. P. R. **1**(3) : 173–175.

1917 *c*. Scale feeding habits of a Porto Rican millipede: *Rhinocricus arboreus* Saussure. Jour. Dept. Agr. P. R. **1** (3) :175-176.

A note on the considerable quantity of *Lepidosaphes beckii* consumed by this millipede.

1917 *d*. Las queresas y cómo combatirlos. Est. Exp. Asoc. Prod. Azúcar P. R. Circ. **9**: 1–7. Also in English as Circ. 9, Bd. Comm. Agr. P. R. Exp. Sta., 7 pp.

A popular article on the control of the more important scale insects.

1917 *e*. Report of the Assistant Entomologist. Ann. Rept. Ins. Exp. Sta. P. R. from 1st July to 30th June, 1917, pp. 106–122, 1 pl. 1 fig.

Notes on insects affecting tobacco, citrus and vegetables, and directions for making oil emulsion for citrus.

1918 *a*. Insectos que atacan las hortalizas en Puerto Rico. Rev. Agr. P. R. **1**(3) : 119–131, 150–165, 198–212, 253–268.

This is a Spanish translation of Cotton 1918 c.

1918 *b*. Experimental work on the control of the white grubs of Porto Rico. Jour. Dept. Agr. P. R. **2**(1) : 1–18.

1918 *c*. Insects attacking vegetables in Porto Rico. Jour. Dept. Agr. P. R. **2**(4): 265–317.

The most complete account to date.

1918 *d*. Medios para combatir los gusanos blancos. Est. Exp. Asoc. Prod. Azúcar P. R. Circ. **12**: 1–7.

Control measures for white grubs in Puerto Rico.

1922. Broad-nosed grain weevil. U. S. Dept. Agr. Bul. **1085**: 1–10, 1 pl.

Caulophilus latinasus Say mentioned as known to occur in Puerto Rico.

* **Cox, O. H., Carrión, A. L., & Fox, C.** 1928. Rat-flea survey of the port of San Juan, Porto Rico—a preliminary report. Pub. Health Rept. **43**(11): 611-616, 2 charts. (Abs. in Rev. Appl. Ent. B **16**: 163–164.)

Results of the survey made 1926–1927 and the species of fleas found and their comparative abundance.

Crawford, J. C. 1913. Descriptions of new Hymenoptera. Proc. U. S. Nat. Mus. Vol. **45**(6): 244.

Ganaspis hookeri as a new species parasitic on *Anastrepha fraterculus* in Puerto Rico.

Crawley, J. T., Johnson, J. R., and **Van Dine, D. L.** 1911. Organización de la estación y cultivo de la caña de azúcar en Puerto Rico. Insectos de la caña y enfermedades de la caña. Est. Exp. de Cañas de la Asoc. Prod. Azúcar P. R., 49 pp. Progress Pub. Co., San Juan.

Crespo, M. A. 1919. El comején (Termes sp.). Rev. Agr. P. R. **3**(6): 35–38, 2 figs.

Brief general account with control measures.

1920. Un insecto muy dañino a las palmitas del coco. El escarabajo rinocerante (*Strategus quadrifoveatus*). Rev. Agr. P. R. **4**(3): 47–48. (Abstracted in L'Agric. Colon., Florence, **14**(7): 314–315, July 1920 under the title "Un insetto molto dannoso al cocco in Portorico," according to Rev. Appl. Ent. **8**: 451.)

Brief general account with control.

Crespo, M. A. and **Catoni, L. A.** 1920. Restricciones legales al comercio de plantas en Puerto Rico. Est. Exp. Ins. Circ. **27**: 1–18.

Cresson, E. T. 1878. Descriptions of North American bees. Proc. Acad. Nat. Sci. Phila., 1875, pp. 188 and 208.

Anthophora krugii and *Melissodes trifasciata* as new species from Puerto Rico.

Cresson Jr., E. T. 1930. Notes and descriptions of some neotropical Neriidae and Micropezidae. Trans. Am. Ent. Soc. **56**: 350.

Taeniaptera (= *Calobata*) *lasciva* Fab. recorded from several localities in Puerto Rico.

Crossman, S. S. and **Wolcott, G. N.** 1915. Cómo dominar la changa. Est. Exp. Asoc. Prod. Azúcar P. R. Circ. **6**: 1–5. Also an English Edition.

Control measures for the changa or West Indian mole cricket.

Cuevas Zequeira, L. 1925. Apicultura. Rev. Agr. P. R. **15**(5): 229–230. Notes on beekeeping in Puerto Rico.

Curran, C. H. 1926. New Diptera from the West Indes. Am. Mus. Novitates No. 220, 14 pp., June 19.

25 new species in 4 families described from Puerto Rico.

1927 *a*. New neotropical and oriental Diptera in the American Museum of Natural History. Am. Mus. Novitates No. 245, 9 pp.

5 new species in 3 families described from Puerto Rico.

1927 *b*. New West Indian Tachinidae. Am. Mus. Novitates No. 260, 15 pp., March 19.

4 new genera and 13 new species described from Puerto Rico.

1928. Insects of Porto Rico and the Virgin Islands. Diptera or two-winged flies. N. Y. Acad. Sci. Surv. P. R. and Virgin Ids. **11**(1): 1–118, 39 figs.

Records about 275 species from Puerto Rico, of which 16 are described as new; 1 new genus; a list is appended of species previously listed from Puerto Rico but not seen by the author.

1930. New species of Diptera belonging to the genus *Baccha* Fabricius (Syrphidae). Am. Mus. Novitates No. 403, 14 pp., February 28.

Baccha deceptor as a new species from Puerto Rico, St. Thomas and St. Croix.

1931 *a*. First supplement to the Diptera of Puerto Rico and

the Virgin Islands. Am. Mus. Novitates No. 456, 23 pp., 4 figs.

1 new genus and 9 new species included in a number of additions to the list for the Island.

1931 *b*. New species of *Chrysopilus* from the neotropical region (Rhagionidae, Diptera). Am. Mus. Novitates No. 462, pp. 4 and 7, March 17.

Chrysopilus macularis and *C. leonardi* as new species from Puerto Rico.

Danforth, R. E. 1924. Notes on the life history of *Disonycha laevigata* Jacoby in Porto Rico. Jour. Econ. Ent. **17**(3): 415-416.

The duration and description of the stages are given for the first time.

Danforth, S. T. 1926. Birds of the Cartagena Lagoon, Porto Rico. Jour. Dept. Agr. P. R. **10**(1): 1–136, 45 figs.

Contains many observations on insects eaten.

1928. El departamento de zoología y entomología [del Colegio de Agricultura e Ingeniería de la Universidad de Puerto Rico]. Rev Agr. P. R. **20**(5): 230 and 245, 1 fig.

Brief account of the plan of instruction in zoology and entomology.

1929. Entomology. Agr. Ext. Leaflet 4, Col. Agr. and Eng. Univ. P. R., 11 pp.

Brief general statement of the subject, with special reference to Puerto Rico.

Davis, Wm. T. 1928. The Cicadas of Puerto Rico with a description of a new genus and species. Jour. N. Y. Ent. Soc. **36**: 29–33, 2 figs. and 1 pl.

Proarna hilaris Germar discussed and *Borencona aguadilla* described as a new genus and species.

Dewitz, H. 1877 *a*. Tagschmetterlinge von Portorico, gesammelt von Herrn Consul Krug. Stett. Ent. Zeit. **38**: 233–245, 1 pl.

The earliest paper on Puerto Rican butterflies, with descriptions of new species and varieties.

1877 *b*. Dämmerungs—und Natchtfalter von Portorico, gesammelt von Herrn Consul Krug. Mitteilungen des Münchner Ent. Vereins **1**: 91–96, pl. 1.

3 new species described from Puerto Rico (Lepidoptera).

1881. Hymenopteren von Portorico. Berl. Ent. Zeit. **25** (pt. 2): 197–208, 1 pl., 12 figs.

11 new species.

Dexter, Raquel R. 1932. The food habits of the imported toad, *Bufo marinus*, in the sugar cane sections of Porto Rico. Proc. Fourth Congress Int. Soc. Sugar Cane Technologists, (Preprint Bul. 74: 1–5), San Juan.

A detailed study of the stomach contents of 301 specimens including identifications of most of the insects found.

Díaz, M. A. 1925. Resultados de la demonstración número 33. Exterminio de hormigas. Rev. Agr. P. R. **14**(1): 38–39.

A brief record of the results obtained in a demonstration in the control of ants in a tobacco seed-bed.

Dikmans, G. 1927 *a*. Report of the parasitologist. P. R. (Mayagüez) Agr. Exp. Sta. for 1925. 22–24.

The horn fly taken on animals from the dry section and larvae of *Hypoderma* found in imported cattle.

1927 *b*. Report of the parasitologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1926, pp. 30–31.

Note on baby chicks infested with the sticktight flea, *Echidnophaga gallinacea*, and notes on lice on cattle and goats.

1929. Report of the parasitologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1927, pp. 27–28.

Several external parasites of domestic animals and poultry recorded.

Dodd, A. P. 1914. A new Proctotrypoid egg parasite from the West Indes. (Hym.). Ent. News **25**: 350.

Phanurus flavus from the eggs of *Ormenis pygmaea* Fab. from Puerto Rico.

Dohrn, Anton. 1860. Beiträge zu einer monographischen Bearbeitung der Familie der Emesina (part 2). Linn. Ent. **4**: 226–227.

Emesa varicornis and *Westermannia tenerrima* as new from Puerto Rico.

1863. Same title as above (part 2). Linn. Ent. **5**: 226–227.

Westermannia tenerrima Dohrn redescribed at greater length from Puerto Rico.

Dozier, H. L. 1925. An outbreak of the red-striped sugar-cane scale. Jour. Dept. Agr. P. R. **9**(4): 357–367, 4 figs.

Description of the various stages and notes on the parasites; *Cheiloneurus pulvinariae* is described as a new species, hyperparasite on *Aphycus flavus* How.

1926 *a*. Some new Porto Rican scale parasites (Hymenoptera, Encyrtidae). Proc. Wash. Ent. Soc. **28**(5): 97–102, 4 figs.

Mercetiella reticulata as a new genus and species and *Euaphycus portoricensis*, new species from *Asterolecanium pustulans* and *Acerophagus nubilipennis*, new species, from *Pseudococcus adonidum* and *P. citri*.

1926 *b*. Some new and interesting Porto Rican leafhoppers. Jour. Dept. Agr. P. R. **10**(3 and 4): 259–265 (Date of publication, Sept. 1927).

Seven species described of which 3 are new.

1926 *c*. Notes on Porto Rican scale parasites. Jour. Dept. Agr. P. R. **10**(3 and 4): 267–277.

Thirteen species treated of which 2 are new, the remainder mostly redescribed.

1926 *d*. Notes on Porto Rican Thysanoptera. Jour. Dept. Agr. P. R. **10**(3 and 4): 279–281.

Locality and food-plant notes on 9 species, of which apparently 5 had not before been recorded from Puerto Rico—*Franklinothrips vespiformis* Cwfd., *Aleurodothrips fascipennis* Fkln., *F. tritici* Fitch, *Haplothrips merrilli* Watson and *Hoplandrothrips reynei* Priesner.

1926 *e*. Annual report of the division of entomology. Ann. Rept. Ins. Exp. Sta. P. R. for 1924–1925, pp. 115–124.

Notes on the status of various injurious insects.

1927 *a*. An undescribed white fly attacking citrus in Puerto Rico. Jour. Agr. Res. **34**(9): 853–855, 3 figs.

Describes all stages of *Paraleurodes naranjae* and records 61.2% of the pupae as parasitized by *Encarsia variegata* How.

1927 *b*. A new Fulgorid from Puerto Rico. Jour. N. Y. Ent. Soc. **35**(1): 53–54, 2 figs.

Rhynchopterx salina from Guánica, Feb., 1925, on *Batis maritima*, "Lirio de mar."

1931. New and interesting West Indian Homoptera. Am. Mus. Novitates No. 510, 24 pp., 18 figs.

New species from Puerto Rico: *Nessorhinus graciloides* (Membracidae); *Thionia borinquensis, Colpoptera maculata, Neocolpoptera* (new genus) *portoricensis* and *N. monticolens* (Fulgoridae).

1932 *a*. Descriptions of new Trichogrammatid (Hymenoptera) egg-parasites from the West Indes. Proc. Ent. Soc. Wash. **34**(3): 36–37.

Ufens osborni from the eggs of *Diaprepes spengleri abbreviatus* L. from Aguirre, P. R.

1932 *b*. The identity of certain whitefly parasites of the genus Eretmocerus Hald., with descriptions of new species (Hymenoptera: Aphelininae). Proc. Ent. Soc. Wash. **34**(7): 112–118, 1 fig.

E. portoricensis as a n. sp. from *Aleurothrixus flocossus* Maskell at Bayamón and Central Aguirre, P. R. in 1925. Stated that this is the species erroneously determined for the writer as *E. californicus* and recorded as an efficient parasite of the woolly whitefly in Ins. Exp. Sta. Circ. P. R. 88: 14, 1925.

1932 *c*. Two undescribed chalcid parasites of the woolly white-fly, Aleurothrixus floccosus (Maskell), from Haiti. Proc. Ent. Soc. Wash. **34**(7): 118–122.

Euderomphale aleurothrixi n. sp. from many males and females from Haiti; a single female from the same host at Central Aguirre, P. R., is thot to be undoubtedly the same species altho the general color is a shade deeper.

Drake, C. J. 1918. Two new Tingids from the West Indies (Hem.—Heter.). Ohio Jour Sci. **18**(5): 174–175.

Leptodictya bambusae from Puerto Rico.

Dyar, H. G. 1907. Descriptions of some American mosquitoes. Jour. N. Y. Ent. Soc. **15**: 13.

Culex toweri Dyar & Knab is described as new from P. R. (=*Culex secutor* Theobald).

1922. New American moths and notes (Lepidoptera). Ins. Insc. Men. **10**(1–3): 10–11.

Agripodes jucundella (Noctuidae) from Puerto Rico.

1924. The male of Anopheles vestipennis Dyar & Knab (Diptera, Culicidae). Ins. Insc. Men. **12**(10): 171.

Described from Puerto Rico.

1928. The mosquitoes of the Americas. Carnegie Institute Pub. No. 387, 616 pp., 418 figs.

All species known to occur in Puerto Rico to date are redescribed.

Earle, F. S. 1920. The cultivation of citrus fruits in Porto Rico. Ins. Exp. Sta. Circ. **26**: 16–17.

Brief discussion of insect pests.

1928. Sugar-Cane and Its Culture (Chapt. 6 "Insect and Other Pests of Sugar-Cane" pp. 162–188, refs. 22.) pp. 355, fig. 94, John Wiley and Sons, New York.

Earle, W. C. 1925 *a*. Malaria surveys in Porto Rico. P. R. Health Rev. **1**(4): 12–18, October.

In part this is a brief report on the malaria survey made 1919; it is stated that "*Anopheles albimanus* would easily appear to be the most important vector, altho at certain seasons *Anopheles grabhami* and *vestitipennis* are quite abundant.

1925 *b*. The relation of irrigation on cane fields to the malaria problem. Agr. Notes P. R. (Mayagüez) Agr. Exp. Sta., Office of Farm Management, No. 21, 3 pp., 1 diagram.

Incidence of malaria, breeding places for Anopheline mosquitoes and management of irrigation ditches discussed.

*1926. Cane field irrigation and malaria. Sugar (Review) **28**: 384, New York, August.

Listed in Pedreira's Bibliographia Puertorriqueña, p. 115, but I have been unable to consult a copy of this volume of Sugar to ascertain its exact contents.

1930. Malaria in Porto Rico. Am. Jour. Trop. Med. **10**(3): 207–230, 8 refs.

A good account of the situation; the 3 species of *Plasmodium* and the 3 species of *Anopheles*—*albimanus, grabhami, vestitipennis* discussed in relation to the disease.

1932. Notes on the life-history of *Anopheles albimanus* and *grabhami*. P. R. Jour. Pub. Health and Trop. Med. **7**: 381–384.

1933. Some observations of antimosquito screening and screening materials. To be published in the March number of the P. R. Jour. Publ. Health & Trop. Med., Vol. 8

Earle, W. C. and **Arbona, Antonio.** 1930. La malaria en Puerto

Rico. Oportunidad que se ofrece a los cañeros como de las mayores entidades que pueden coadyudar a su restricción. Rev. Agr. P. R. **24**(12) : 235–239.

A general discussion of work both done and to be done in an effort to reduce malaria, especially in the South Coast sugar growing sections, by means of proper location of workers' colonies, drainage, etc., in order to reduce the possibilities of transmission by mosquitoes.

Erichson, G. F. 1839–1840. Genera et species Staphylinorum insectorum coleopterorum familae, pp. 79–910.

Included within the range of the above cited pages are 26 species distributed in 19 genera described as new from Puerto Rico.

Erichson, G. F. in Germar, E. F. 1843. Versuch einer systematischen Eintheilung der Nitidularien. Zeit. für die Ent. **14**: 245.

Colastus infimus Er. as a new species from N. Am., Puerto Rico and Brazil (=*Colopterus truncatus* Randall).

Fauvel, Albert. 1895. Notes synonymiques. Rev. d'Ent., **14**: 106.

Olibrus parki var. *erithacus* Chevr. mentioned as occurring in Puerto Rico (as *Eurestus erithacus*).

Faxon, Richard and **Trotter, C. P.** 1932. Plant quarantine service in Porto Rico. Jour. Econ. Ent. **25**(3) : 435–447.

A detailed historical account with notes on the principal insects quarantined against and on the more important species injurious to several of the leading crops.

Felt, E. P. 1913. Three new gall midges (Diptera). Can. Ent. **45**(9) : 304–305.

Karschomyia cocci and *Mycodiplosis insularis* described from Puerto Rico.

1914. Arthrocnodax constricta n. sp. Jour. Econ. Ent. **7** (6) : 481.

Reared from garden beans & probably predaceous on *Tetranychus bimaculatus*, T. H. Jones Coll., Río Piedras.

1932. A new cambium miner of citrus in Puerto Rico. Jour. Dept. Agr. P. R. **16**(2) : 117–118.

Asynapta citrinae reared by G. N. Wolcott at Isabela, 1931.

Fernald, Mrs. M. E. 1903. A catalogue of the Coccidae of the world, Amherst, Mass., pp. 259–260.

Aspidiotus forbesi listed as occurring in Puerto Rico.

Fernández de Oviedo, Gonzalo. 1535. Historia general y natural de las Indias.

Fifty volumes published of which Book 16 and some chapters of others relate to Puerto Rico; included in the Biblioteca Histórica de Puerto Rico by Tapia, which see.

Ferris, G. F. 1922. Notes on Coccidae IX. Can. Ent. **54**(7): 160–161, fig. 4.

Cryptostigma (*Pseudophillipia*) *inquilina* on *Inga laurina* described from Puerto Rico as *C. ingae* new species.

[**de la Ferté-Senectere, M. F.** 1848. Monographie des Anthicus et genres voisins, coléoptères hétéromeres de la tribu des Trachélides. p. 157. Paris.

Wolcott on p. 85 of his "List" states that the type of *Anthicus vicinus* is given as "'America borealis' from Puerto Rico" but an examination of the original description does not show any mention of Puerto Rico or any such definite locality.]

Figueroa, C. A. 1924. Demonstraciones Agrícolas. P. R. Dept. Agr. y Trab., Div. Fomento Circ. 3, pp. 1–65, several figs.

Notes on demonstrations in the control of the sweet potato weevil, *Cylas formicarius*, pp. 20–25, on tobacco insects, pp. 26–28, 30 on the changa, *Scapteriscus vicinus*, p. 29, on onions and on tobacco, p. 31, and on insects affecting stored seeds, pp. 32–36.

1926 *a*. Demostraciones agrícolas, 1924–25. Represión de enfermedades y plagas. Dept. Agr. y Trab. P. R. Circ. de Fomento No. **7**: 107–138.

This chapter outlines methods and results of a number of demonstrations in the practical control by the official Agricultural Agents of a number of the more important crop pests in the Island.

1926 *b*. Algunos problemas agrícolas de Puerto Rico y sus soluciones. P. R. Dept. Agr. y Trab., Div. Fomento, Circ. 8, pp. 1–32, several plates.

Notes on demonstrations on the control of the sweet potato weevil, *Cylas formicarius*, the banana root-weevil, *Cosmopolites sordidus*, and the cattle tick.

Fischer, von W. G. 1888. Drei neue Anthonomus. Berl. Ent. Zeitschr. **32**(2): 487–489.

Anthonomus krugii, *A. nigrovariegatus* and *A. annulipes* described from Puerto Rico.

Fisher, W. S. 1918. Chrysobothris tranquibaricus Gmel. ver-

sus impressa Fabr. (Coleoptera, Buprestidae). Proc. Ent. Soc. Wash. **20**(8) : 174 and 176.

Chrysobothris fraterna Mann described from Puerto Rico in Bul. Soc. Imp. Moscou 10(8) : 75–76, 1837 is listed as a synonym.

1925 *a*. A revision of the West Indian Coleoptera of the family Buprestidae. Proc. U. S. Nat. Mus. Vol. **65**, Art. 9(2522) : 1–207.

Acmaeodera gundlachi, p. 45, *Chrysobothris wolcotti*, p. 119, and *Taphrocerus elegans*, p. 187 described as new species from Puerto Rico.

1925 *b*. New West Indian Cerambycidae (Coleoptera). Subfamily Lamiinae. Am. Mus. Novitates No. **174**, 16 pp., May 28.

Leptostylus gundlachi and *L. antillarum* as new species from Puerto Rico.

1926. Descriptions of new West Indian longicorn beetles of the subfamily Lamiinae. Proc. U. S. Nat. Mus. Vol. 68, Art. 22(2623) : 15–16.

Leptostylus longicornis as a new species from the Ins. Exp. Sta., Río Piedras, P. R.

1930 *a*. Notes on the rhinotraginae beetles of the family Cerambycidae, with descriptions of new species. Proc. U. S. Nat. Mus. Vol. 77, Art. 19(2842) : 1–20.

Acyphoderes aurulenta Kirby recorded from Puerto Rico is probably the species recorded as *abdominalis* by Gahan and by Leng & Mutchler and mentioned in Wolcott's "List".

1930 *b*. New West Indian Buprestidae (Coleoptera). Proc. Wash. Ent. Soc. 32(7) : 128–129.

Neotrachys hoffmani described from Puerto Rico.

1932. New West Indian Cerambycid beetles. Proc. U. S. Nat. Mus. 80 (Art. 22) : 1–93.

Brittonella (new genus) *chardoni*, *Eburia portoricensis*, *Elaphidion portoricensis*, *Stizocera vanzwaluwenburgi*, *Tilloclytus minutus*, *Lamproclytus elegans* (new genus), and *Ecyrus nanus* and *E. flavus* described as new from Puerto Rico.

Fletiaux, Ed. 1897. Liste des Eucnemidae du musée de Berlin et description des espéces nouvelles. Ann. Soc. Ent. Belgique **41** : 256.

Arrhipis lanieri Guer. listed from Puerto Rico.

Folsom, J. W. 1923. A new Lepismid from Puerto Rico. Proc. Ent. Soc. Wash. **25**(7–8) : 169–170, pl. 14, figs. 1–8.

Ctenolepisma reducta.

1927. Insects of the Subclass Apterygota from Central America and the West Indies No. 2702. Proc. U. S. Nat. Mus. Vol. 72, art. 6, pp. 1–16 pl. 8.

Salina wolcotti and *Lepidocyrtus nigrosetosus* described.

Forbes, W. T. M. 1917. Notes on West Indian Syntomidae and Arctiidae (Lepidoptera). Bul. Am. Mus. Nat. Hist., Art. 14, **37** : 339–345.

Lymire senescens as a new species (= *L. flavicollis* DeW.) from Puerto Rico; *Eunomia columbina* (F.) recorded from Puerto Rico; variation in *Utetheisa ornatrix* L. is discussed.

1930. Insects of Porto Rico and the Virgin Islands. Heterocera or moths (excepting the Noctuidae, Geometridae and Pyralidae). N. Y. Acad. Sci. Surv. P. R. and the Virgin Ids. **12**(1) : 1–171, 2 pls.

One hundred seventy-four species are treated, mostly Puerto Rican, of which 6 new species and 1 new race are described from Puerto Rico; keys to the families, genera and species are given.

1931. Supplementary report on the Heterocera or moths of Puerto Rico. Jour. Dept. Agr. P. R. **15**(4) : 339–394, 6 pls.

Four new genera and 37 new species included. Also reprinted without change of title or pagination as a supplement to the preceding title.

1932. The rubidella group of Aristotelia. Jour. N. Y. Ent. Soc. **40**(4) : 423–433.

Aristotelia diolcella and *A. vagabundella* mentioned as having been described from Puerto Rico.

Forbes, W. T. M. and **Leonard, M. D.** 1930. A new leaf-miner of cotton in Porto Rico. Nepticula gossypii new species. Jour. Dept. Agr. P. R. **14**(3) : 151–157, 2 pls.

Distribution, life-history, description of stages, nature of injury and suggestions for control.

Frost, S. W. 1931. New species of West Indian Agromyzidae (Diptera). Ent. News **42** : 74–75.

Agromyza ipomeae described as a leaf-miner of sweet potato in Puerto Rico.

Funkhouser, W. D. 1930. New genera and species of neotropical Membracidae. Jour. N. Y. Ent. Soc. **38**: 413–414, pl. 23, fig. 12.

Spinodarnoides typus described as a new genus and species from Puerto Rico.

Gahan, A. B. 1915. Descriptions of new genera and species, with notes on parasitic Hymenoptera. Proc. U. S. Nat. Mus. **48**: 1–165.

Diaulinus insularis (Eulophidae) described from Puerto Rico as parasitic on *Agromyza inaequalis* Malloch.

1927. Miscellaneous descriptions of new parasitic Hymenoptera with some synonymical notes. Proc. U. S. Nat. Mus. **21** (Art. 4, No. 2676): 1–39, 1 pl., 3 figs., 8 refs.

Prospaltella ciliata described as a new species from *Aleurodicus* sp. in Puerto Rico.

1930. Synonymical and descriptive notes on parasitic Hymenoptera. Proc. U. S. Nat. Mus. Vol. **77** (Art. 8, No. 2831): 1–11.

Telenomus sphingis Ashm. reared from the eggs of *Phlegethontius sexta* Joh. by W. V. Tower at Gurabo, P. R., (previously determined by J. C. Crawford as *T. monilicornis*).

1932. Miscellaneous descriptions and notes on parasitic Hymenoptera. Ann. Ent. Soc. Am. **25** (4): 736–757.

Apanteles laevigatus Asm. mentioned as occurring in Puerto Rico, p. 737 and *Grotiusomyia nigricans* How, recorded as received thru the P. Q. & C. A. bred from (*Lamprosema*) *Hedylepta indicata*, the bean leaf webber, from Puerto Rico.

Gahan, C. J. 1895. On the longicorn Coleoptera of the West India Islands. Trans. Ent. Soc. London, pp. 79–140, 2 pls.

A number of Puerto Rican records including *Eburia bindosa* as a new species from Puerto Rico. This is possibly a synonym of *E. quadrimaculata* L.

Gerstaecher, Carl E. A. 1860. Die Arten der Gattung Lissomus Dalm. Linn. Ent. **14**: 169.

Drapetes chalybaeus described as a new species from Puerto Rico (as *Lissomus*).

Gibson, E. H. 1917. Two new species of Dicyphus from Porto Rico. Can. Ent. **49** (6): 218–219.

D. prasinus and *D. luridus*.

Girault, A. A. 1916. Descriptions of miscellaneous chalcid-flies. Insec. Inscit. Men. **4**(11–12) : 111–113.

Eurytoma ctenodactylomyii and *Neocatolaccus livii* as new species from Puerto Rico.

Gómez, J. C. 1928. La vaquita de la caña. Rev. Agr. P. R. **20**(5) : 238 and 256.

Brief popular account of *Diaprepes spengleri* in Puerto Rico.

González, Manuel. 1924. Resultados obtenidos en una demonstración cuyo propósito fué controlar la changa y el gusano prieto del tabaco en una plantación. Rev. Agr. P. R. **13**(6) : 403.

González Ríos, Policarpo. 1920. Cultivo del banano en Puerto Rico. Est. Exp. Ins. P. R. Bol. **25**, 27.

Brief note on injury of *Phyllophaga* and *Diaprepes* injury to the banana in Puerto Rico; stated that insects are not very injurious.

1921. El cultivo del cocotero en Puerto Rico. Ins. Exp. Sta. P. R. Circ. **35** : 1–20. 4 figs.

The insect enemies of the coconut in Puerto Rico include the scales *Aspidiotus destructor* and *Vinsonia stellifera* and the rhinoceros beetle, *Strataegus quadriforcatus*; brief account with control.

1922. El gorgojo de banano. Rev. Agr. P. R. **9**(6) : 39–42.

Brief popular account of the banana root weevil, *Cosmopolites sordidus*, in Puerto Rico.

1923. El gusano del cogollo de la yuca. Rev. Agr. P. R. **10**(4) : 45–46.

Brief popular account of the cassava or yuca shoot-borer, *Lonchaea chalybea* Wied. in Puerto Rico.

1930. Cultivo del banano en Puerto Rico. Est. Exp. Ins. P. R. Bol. **36** : 47–51.

Brief discussion of the root-weevil and other insects attacking the banana in Puerto Rico with suggestions for control.

González Ríos, P. and **Mayoral Reinat, A.** 1931. El cultivo del aguacate en Puerto Rico. Est. Exp. Ins. P. R. Circ. **93** : 30–31.

Brief account of the more important insects affecting the avocado in Puerto Rico.

Gould, H. P. 1904. Indicaciones prácticas sobre el cultivo de frutas. Dept. Int. P. R., Neg. Agr. y Minas, Bol. Agr. **19**, pp. 5–22.

A Spanish translation of U. S. Farmers' Bul. 161 "Practical suggestions for fruit growers," 1902. This contains a discussion of spraying for the control of insects and diseases and descriptions of special uses of the various types of spray machines.

Gundlach, Juan. 1887, 1891 and 1894. Apuntes para la fauna Puerto-Riqueña. Ann. Soc. Espan. Hist. Nat. 16, 20 and 22. Part 8 of the whole deals with insects starting on p. 137 of Vol. **16** with the various orders as follows:

1887. Vol. **16**: 139–150, Orthoptera; 150–174: Hymenoptera; 174–199, Diptera.

1891. Vol. **20**: 323–384, Lepidoptera.

1894. Vol. **22**: 261–273, Neuroptera (incl. Odonata): 274–287, Hemiptera; 287–344, Coleoptera.

No new species are described but many scattered biological notes are included.

de Haan, Willem. 1842. Bijdragen tot de Kennis der Orthoptera. Verhand. de Natur. Gesch. der Nederl. Overzeesch. Bezitt. etc., Orthoptera, p. 102. Leiden.

According to Wolcott's "List" on p. 23 *Bacteria calamus* (Phasmidae) is described from Puerto Rico as a new species. I fail to find any mention of this species in this work. *B. spinosus* Burm. is, however, listed from Puerto Rico.

Hall, Maurice. 1929. Parásitos del ganado en América Latina. Rev. Agr. P. R. **22**(8): 56 and (9): 117.

A general account of the principal external and internal parasites of animals in Latin America, including control measures; several of of the more important insect pests such as cattle ticks, and the horn fly of cattle are briefly mentioned on p. 60 specifically as being troublesome in Puerto Rico.

Hampson, Geo. F. 1898-1920. Catalogue of the Lepidoptera Phalaenae in the British Museum. 13 Vols. and 2 Suppls.

The above are all that have been published to date and include the Syntomidae, Arctiidae, Agaristidae (only 1 species in Puerto Rico), and Noctuidae, (in part, about two-thirds). There are descriptions of many species specifically stated as ocurring in Puerto Rico.

Harris, H. M. 1928. A monographic study of the hemipterous family Nabidae as it occurs in North America. Ent. Am. **9** (N.S.) (1 and 2): 77–78.

Carthasis gracilis Harris listed from Puerto Rico.

Hebard, Morgan. 1916. Studies in the group Ischnopterites.

(Orthoptera, Blattidae, Pseudomopinae). Trans. Am. Ent. Soc. **42**(4) : 367, pl. XVIII, figs. 14–17.

Symploce flagellata as a new species from Puerto Rico (Blattidae).

Henricksen, H. C. 1906 *a*. Vegetable growing in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Bul. **7**: 18–20, 2 figs.

A brief general account of insect pests: two classes of insects-biting and sucking affecting vegetables; the formulae for several of the standard insecticides are given and two types of small sprayers are suggested.

1906 *b*. Report of the horticulturalist. Insect pests. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1905, pp. 27–28.

Brief notes on several scales, June beetles, and ants with suggestions for control.

1930. Citrus culture in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Bull. **33**: 27–30.

A brief general account of the more important citrus insects and their control.

Henricksen, H. C. and **Iorns, M. J.** 1909. Pineapple growing in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Bul. **8**, p. 38.

The mealybug, *Pseudococcus brevipes* Ckll., and its attendant ant are mentioned; tobacco dust is recommended.

Hernández, Elías 1925. Represión del pulgón amarillo de la caña. Resultado de las demostraciones Nos. 12 y 13. (Contribución de la División de Fomento Agrícola). Rev. Agr. P. R. **14**(6) : 358–360.

Notes on a demonstration for the control of the yellow cane aphis, *Sipha flava*, with nicotine dust at San Germán.

Hernández, Elías and **Ramírez López, Carlos**. 1925. **Represión** de la oruga de la hoja del algodón. Demostración No. 3. (Contribución de la División de Fomento.) Rev. Agr. P. R. **14**(1) : 43–44.

Better results obtained in the control of the cotton leafworm by arsenate of lead dust than by spray.

Herrera, Antonio de. (1565–1625). Historia general de las Indias.

This work comprises 8 "decadas" the first to the fifth referring to Puerto Rico. Decada 2, libro 3, chapter 14, pp. 110–112, year 1518 refers to the ant plague in Hispaniola (Santo Domingo) and in San Juan, Puerto Rico, and the remedy therefore.

Hinds, W. E. 1903. El bisulfuro de carbono como insecticida. Dept. Interior. P. R. Neg. Agr. y Minas, Bol. Agr. **17**: 19–40. San Juan, November.

A translation of U. S. Farmers' Bul. 145, 1902 on "Carbon bisulfid as an insecticide.

Hoffman, Wm. A. 1925. A review of the species of Culicoides of North and Central America and the West Indies. Am. Jour. Hygiene **5**(3) · 285–289.

C. phlebotomus Will. and *C. furens* Poey recorded from Puerto Rico.

1927. A container for field collection of mosquito larvae. Science 66: 484, 1 fig.

Description and diagram of the container.

1932. *Icerya purchasi* in Puerto Rico. Jour. Econ. Ent. **25** (3): 726.

Brief note of its occurrence on casuarina (Australian pine) in San Juan proper.

Hoffman, W. A., Marín, R. A. & Burke, A. M. B. 1928. Filariasis in Porto Rico. P. R. Rev. Pub. Health & Trop. Med. **4**(3): 120–127, 1 map. (Abs. in Rev. Appl. Ent. B **17**: 115).

Preliminary results of surveys in 31 localities; *Culex fatigans* found in all localities examined but scarcer in higher altitudes.

Holloway, T. E. 1915. Fighting the sugar-cane borer with parasites and poisons. Reprint from the Louisiana Planter and Sugar Manufacturer, December 18.

Reference is made to Wolcott's observation that borer infestation in Puerto Rico is inversely proportional to the amount of rainfall.

Holloway, T. E., Haley, W. E. and Loftin, U. C. 1928. The sugar-cane moth borer in the United States. U. S. Dept. Agr. Tech. Bul. **41**, 76 pp., 1 pl. and 25 figs.

Several references are made to *Diatraea saccharalis* Fab. in Puerto Rico.

Holloway, T. E. and Loftin, U. C. 1919. The sugar-cane moth borer. U. S. Dept. Agr. Bul. **746**, 74 pp., 9 pls., 12 figs.

On pp. 35–36 Wolcott's observations in Puerto Rico on rainfall and borer abundance are again referred to.

* **Holmer, E. and Little, L. L.** 1921. Porto Rico, beehive and orchard. Travel **36**: 22, January, New York.

Hood, J. D. 1913 *a*. Two new Thysanoptera from Porto Rico. Insec. Inscit. Men. **1**(6) : 65–70, 1 pl.

Heterothrips sericatus as a new species and *Podothrips semiflavus* as a new genus and species from Puerto Rico.

1913 *b*. On a collection of Thysanoptera from Porto Rico. Insec. Inscit. Men. **1**(12) : 149–154, 1 pl.

Dinurothrips hookeri as a new genus and species from Puerto Rico.

1914. Two Porto Rican Thysanoptera from sugar cane. Insec. Inscit. Men. **2**(3) : 38–41.

Heliothrips (?) *tibialis* as a new species and notes on *H. femoralis* Reuter. These are both in Wolcott's "List" on p. 239 under *Haplothrips.*

Hooker, C. W. 1912. The Ichneumon flies of America belonging to the tribe Aphioninae. Trans. Am. Ent. Soc. **38** : **144**, pl. II, fig. 13.

Eremotylus angulatus as a new species from Puerto Rico.

1913 *a*. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1912, pp. 34–38.

Notes on insect pests of coffee, mango, citrus and sugar cane and on apiculture; distribution of two Coccinellid beetles—*Cryptolaemus montrouzeri* from Río Piedras to Mayagüez and *Hippodamia convergens* introduced from California; also of the occurrence of the papya fruit fly, *Toxotrypana curvicauda* at Mayagüez.

1913 b. Entomological conferences in Porto Rico. Jour. Econ. Ent. **6**: 148–150.

A brief report on two conferences of the workers in entomology in Puerto Rico; an annotated list is given of the 9 papers read at the second conference, presented by as many individuals, which summarize the progress on several of the major projects under investigation.

Hottes, F. C. and **Frison, T. H.** 1931. The plant lice, or Aphiidae, of Illinois. Bol. Div. Nat. Hist. Surv. Ill. **19**, Art. 3, p. 174.

Sipha flava Fbs. stated as being frequently a serious pest of young sugar cane in Puerto Rico.

Howard, L. O. 1930. A history of applied entomology. (Somewhat Anecdotal). Smithsonian Misel. Coll. **84** (Whole Volume). Publ. 3065, pp. 457–460 and 523.

A brief resumé of applied entomology in Puerto Rico on pp. 457–460; on p. 523 are brief notes on parasite introductions.

Howard, L. O., Dyar, H. G. and **Knab, Fred.** 1912–1917. Mosquitoes of North and Central America and the West Indies. Carnegie Institute of Washington Publ. No. 159; **1**: 1–520, 1912; **2**, 150 pls. of 711 figs.; 1912; **3**: 1–523, 1915; **4**: 524–1064, 1917.

All the species, old and new, known to occur in the territory covered, including Puerto Rico, are herein described.

Hutson, J. C. 1917 *a*. Some weevils of the genus Diaprepes in the West Indies. Agr. News. Barbados, B. W. I. **61** (398): 186.

Diaprepes doubleri, spengleri and *abbreviatus* listed as occurring in Puerto Rico.

1917 *b*. White grubs injuring sugar cane in Porto Rico. Agr. News, Barbados, B. W. I. **16** (397): 218–219; (398): 234. (399): 250–251.

The paper by E. G. Smyth on white grubs injurious to cane in Puerto Rico in Jour. Dept. Agr. P. R. 1 (2), 1917 is abstracted at some length.

1917 *c*. Sugar cane white grubs in Porto Rico. Agr. News, Barbados, B. W. I. **16** (404): 330–331.

Abstract of the continuation of the above paper by Smyth in Jour. Dept. Agri. P. R. 1 (3), 1917.

* **Iches, M. Lucien.** Date? La abeja doméstica. p. 368.

Colón, E. D. 1930, in foot note No. 6 on page 158 says that it is here stated that the nrst bees imported into Puerto Rico and Cuba were *Apis mellifica* but that later there were imported into North America the Italian and Egyptian races.

* **Illiger, J. C. W.** 1807. Monographie der Elateren mit leuchtenden Flecken auf dem Halsschilde. Mag. Gesellschaft. Nat. Freund. Berlin 1, p. 149.

Pyrophorus luminosus described as a new species from Puerto Rico.

Jacoby, Martin. 1888. Biol. Centr. Am. Coleoptera, **6**, Pt. 1, pp. 616–617.

Cerotoma ruficornis Oliv. listed from Puerto Rico.

Javiere, Clemente. 1932. Enfermedades y plagas que atacan al plátano. Bol. Agr. (P. R.) No. **30**, p. 3, March 5.

Brief note on injury and control of the banana root weevil, *Cosmopolites sordidus*.

Johnson, H. A. 1926. Occurrence of *Anopheles vestipennis* in Porto Rico. Am. Jour. Trop. Med. **6**(2): 153–155.

First record of larva and adult male obtained during investigations in 1924–1925 with notes on seasonal abundance of the species.

Johnston, J. R. 1915. The entomogenous fungi of Porto Rico. Bd. Comm. Agr. P. R. Bul. **10**, 33 pp., 9 pls.

Descriptions of the species known to be present with notes on them and on the insects which they are known to parasitize in Puerto Rico.

Jones, T. H. 1913. Some notes on Laphygma frugiperda S. & A. in Puerto Rico. Jour. Econ. Ent. **6**(2): 230–236.

1914. Additional notes on Porto Rican sugar-cane insects. Jour. Econ. Ent. **7**:(6)461–463.

Brief notes on determinations of specimens by various specialists and on synonomy of several species.

1915 *a.* Aphides or plant-lice attacking sugar-cane in Puerto Rico. Bd. Comm. Agr. P. R. Bul. **11**, 19 pp., 2 figs.

1915 *b.* La mariposa-barreno del tallo de la caña de azúcar (Diatraea saccharalis Fabr.). Junta de Com. Agr. P. R. Bol. **12**, 31 pp., 6 figs.

1915 *c.* The sugar-cane weevil root-borer (*Diaprepes spengleri* L.). Bd. Comm. Agr. P. R. Bul. **14**: 1–19, 11 figs.

1915 *d.* Insects affecting vegetable crops in Porto Rico. U. S. Dept. Agr. Bul. **192** (professional paper), 11 pp., 4 pls.

General account of more important species concerned with control measures.

1917 *a.* A list of the Coccidae of Porto Rico. Jour. Dept. Agr. P. R. **1**(1): 1–16, 26 references.

Notes on the food-plants and distribution of 50 species are given.

1917 *b.* The sweet-potato leaf-folder. U. S. Dept. Agr. Bul. **609**: 1–12, 4 figs.

Pilocrocis tripunctata F. mentioned on p. 2 as injurious in Puerto Rico.

Jones, T. H. and **Wolcott, G. N.** 1922. The caterpillars which eat the leaves of sugar cane in Porto Rico. Jour. Dept. Agr. P. R. **6**(1): 38–50, 10 figs.

Seven species of caterpillars do minor leaf-injury to sugar cane

leaves, of which notes and original observations are given for six of these.

J. R. 1923. Destrucción de los insectos por medio del petróleo. Rev. Agr. P. R. **11**(4): 19–21.

Brief general directions for the use of petroleum emulsions for the control of various groups of injurious insects.

Kellogg, Vernon L. 1905. American Insects, p. 161, fig. 230.

Mention made of the losses caused by the "changa" or Porto Rican mole cricket in Puerto Rico.

* **King, W. W.** 1917. The epidemic of dengue in Porto Rico, 1915. New Orleans Med. Surg. Jour. **49**(8): 564–71. (Abs. in Rev. Appl. Ent. Ser. B. **65**: 61.)

Culex and Aedes, the common mosquitoes in San Juan, were especially numerous at the time of the epidemic.

* **Kinman, C. F.** 1918. The mango in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Bul. **24**: 1–30, 11 pls.

A thrips and the fruit-fly, *Anastrepha fraterculus*, stated to be the only insects of importance; recommends enclosing fruits in paper bags for the control of the latter. (Abs. in Rev. Appl. Ent. 6: 392).

Klots, A. B. 1929. A revision of the genus Eurema Hübner. Ent. Amer. **9**(3), n. ser., p. 132, fig.

E. portoricensis Dewitz mentioned as occurring only in Puerto Rico.

Klots, Elsie Broughton. 1932. Insects of Porto Rico and the Virgin Islands. Odonata or dragon flies. N. Y. Acad. Sci. Surv. P. R. and the Virgin Ids. **14**(1): 1–107, 7 pls.

Thirty-eight species treated as occurring in Puerto Rico; none new.

Knab, Fred. 1915. Some West Indian Diptera. Insc. Inscit. Men. **3**(4): 48–49.

Tabanus hookeri as a new species from Mayagüez, 1 male and 1 female, collected by Van Zwaluwenburg.

Koch, C. 1842. Die Arachniden, **9**: 66–67, pl. cccx, fig. 732, 83–84, pl. cccxvii, fig. 744.

Mygale laeta, p. 66 and *Avicularia* (as *Mygale*) *caesia* as new species from Puerto Rico.

Kolbe, H. J. 1888. Die geographische verbreitung der Neuroptera und Pseudoneuroptera der Antillen nebst einer Übersicht über die von Herrn Consul Krug auf Portorrico gesammelten

Arten. Neuroptera v. d. Sammlung von Herr Krug. Archiv. für Naturgeschichte, 46th year, **1**(2): 153–178, pl. 13, 11 figs.

An important paper on Puerto Rican Neuroptera.

1907. Ueber die Arten der Amerikanischen Dynastidengattung Strataegus. Berl. Ent. Zeit. **51**(1906): 1–32, 1 pl., 8 figs.

S. quadrifoveatus on p. 21 and 32 and *S. titanus* on p. 31 listed from Puerto Rico..

1910. Ueber die Phileurinen Amerikas. An. Soc. Ent. Belgique **54**: 341.

Homophileurus quadrituberculatus P. de B. listed from Puerto Rico.

Kruger, Wilh. 1899. Das Zuckerrohr und seine Kultur mit besonderer Berücksichtigung der Verhaltnisse und Untersuchungen auf Java, p. 312.

In a foot-note *Delphax saccharivora* Westw. is listed from Puerto Rico.

* **Kudo, R.** 1930. Studies on Micosporidia parasitic in mosquitoes. viii. On a Miscosporidian, *Nosema aedis* nov. spec., parasitic in a larva of *Aedes argenteus* (*aegypti*) of Puerto Rico. Archiv. Protistenk. **49**(1): 23–38, 2 pls., 47 refs. Jena, Jan. 15. (Notice by title in Rev. Appl. Ent. B 18: 87).

Lacordaire, J. T. 1845. Monographie des coléopteres subpentameres de la famille des Phytophages, Vol. I. Mem. Soc. Roy. Sci. Liege **3**: 355–356.

Lema polita described as a new species from Puerto Rico.

Langston, J. M. 1923. The tobacco leaf-folder of Porto Rico attacks tomatoes in Mississippi. Qtly. Bul. State Plant Bd. Miss. **2**(4): 7–9.

Notes on the discovery of *Pachyzancla periusalis* Wlk. in Miss. in Oct., 1922 and on its activities in Puerto Rico.

Lathy, P. I. 1899. Monograph of the genus *Calisto* Hübner. Trans. Ent. Soc. London, Part 2, pp. 221–228, pl. IV.

Calisto nubila described as a new species from Puerto Rico.

Ledru, Andrés Pedro. 1810. Viaje a la Isla de Puerto Rico en el año 1797. Paris. 2 Vols.

Forty-six species of insects listed from the Island. This is the earliest recorded collection of insects from Puerto Rico. Of those listed Wolcott indentifies 10 species in his "List" and states that the probable identity of many of the rest can be guessed.

* **Leefmans, S.** 1915. De cassave-oerets. [The cassava grubs]. Dept. Nijverheid, Landbow en Handel.—Med. van het Laboratorium voor Plantenzeikten, No. 13, 118 pp., 7 pls., 4 tables of curves. (Abstract in Rev. Appl. Ent. **4**: 82–84).

In the discussion of natural enemies reference is made to attempts which had been made to obtain beneficial parasites from Puerto Rico but which were unsuccessful.

Legrand, J. F. 1921. El gusano rosado del algodón (*Pectinophora gossypiella*). Rev. Agr. P. R. **7**(3): 9–13.

Brief general account of the pink bollworm.

1923. Notas de interés. Entomología. Rev. Agr. P. R. **10**(4): 49–50.

Notes on the sweet potato weevil and the cotton pink bollworm.

Leng, C. W. and **Mutchler, A. J.** 1914. A preliminary list of the Coleoptera of the West Indies as recorded to January 1, 1914. Bul. Am. Mus. Nat. Hist. **33** (Art. 30): 391–493.

Many species listed from Puerto Rico.

1916. Descriptive catalogue of West Indian Cicindelinae. Bul. Am. Mus. Nat. Hist. 35 (Art. 36): 681–699, pl. 1, 5 figs.

Five species occurring in Puerto Rico treated; none new.

1917. Supplement to preliminary list of the Coleoptera of the West Indies. Bul. Am. Mus. Nat. Hist. **37** (Art. 5): 191–220.

1922. The Lycidae, Lampyridae and Cantharidae (Telephoridae) of the West Indies. Bul. Am. Mus. Nat. Hist. **46** (Art. 8): 413–499, 65 figs.

Seven species described as new from Puerto Rico.

Leonard, M. D. (See also under Forbes 1930, Mills 1931, and Pemberton 1932).

1930 *a*. An unrecorded food-habit of the large tobacco suck-fly in Porto Rico. Jour. Econ. Ent. **23**(3): 640–641.

Brief note on injury to tobacco blossoms by *Dycephus luridus* Gibson.

1930 *b*. A little-known root-weevil of cassava (*Coelosternus sulcatulus* Boehman). Jour, Dept. Agr. P. R. **14**(3): 159–165, 1 fig. and 3 pls.

Notes on injury and description of stages with a redescription of the adult of this rare weevil.

1930 *c*. Plagas de insectos de la cual está libre la caña en Puerto Rico. Rev. Agr. P. R. **25**(2): 62–63, 93–94.

A summary of the distribution, life history, injury and control of several important sugar cane insects not as yet occurring in Puerto Rico.

1930 *d*. Recomendaciones para combatir las plagas que afectan en Puerto Rico al cultivo del algodón. El Mundo (San Juan), Oct. 14, pp. 3, 9, 11. Reprinted under the same title in Rev. Agr. P. R. **25**(4): 135–136, 163–164. Also issued in mimeographed form by the Ins. Exp. Sta. as "Notas".

Suggestions for the control of the more important cotton insects in Puerto Rico.

1931 *a*. Entomology in Puerto Rico during the past decade. Jour. Econ. Ent. **24**(1): 141–151.

1931 *b*. *Leptoglossus gonagra* Fab. injuring citrus in Porto Rico. Jour. Econ. Ent. **24**(3): 765-767.

1931 *c*. A bibliography of the banana root weevil. Jour. Dept. Agr. P. R. **15**(2): 147–176.

Two hundred fifteen titles, annotated, on the world literature of *Cosmopolites sordidus*.

1931 *d*. Report of the division of entomology for the fiscal year 1929–30. Ann. Rept. Ins. Exp. Sta. P. R. for 1929–30, pp. 110–123.

Notes on insects of sugar cane, the banana root weevil, a citrus insect survey proposed, on cotton insects and silk worm culture; a brief insect pest survey for the year is included and cooperation with the Scientific Survey of P. R. & the Virgin Ids. as well as other projects referred to.

1931 *e*. Insect conditions in Porto Rico during the fiscal year ended June 30, 1930. Insect Pest Surv. Bul. **11**(1): 33–37.

1931 *f*. Insect conditions in Porto Rico during January and February, 1931. Ins. Pest Surv. Bul. **11**(2): 76–78.]

1931 *g*. Insect conditions in Porto Rico during April 1931. Ins. Pest Sur. Bul. **11**(4): 235–238, June 1.

1931 *h*. Insect conditions in Porto Rico during May, 1931. Ins. Pest Surv. Bul. **11**(5): 317–319, July 1.

1931 *i*. Insect conditions in Porto Rico during June, 1931. Ins. Pest Surv. Bul. **11**(6): 409–412, August 1.

1931 *j*. Insect conditions in Porto Rico during July, 1931. Ins. Pest Surv. Bul. **11**(7): 492–494, September 1.

1931 *k*. Insect conditions in Porto Rico during August, 1931. Ins. Pest Surv. Bul. **11**(8): 574–577, October 1.

1931 *l*. Insect conditions in Porto Rico during September, 1931. Ins. Pest Surv. Bul. **11**(9): 642–645.

1932 *a*. The initiation of an insect pest survey in Porto Rico. Jour. Dept. Agr. P. R. **16**(1): 59–64.

1932 *b*. The pink bollworm of cotton in Porto Rico. Jour. Dept. Agr. P. R. **16**(1): 65–73.

A rather detailed account of the present status of the insect.

1932 *c*. Additional references to the bean lacebug. Jour. Dept. Agr. P. R. **16**(1): 75–76.

Additions to the bibliography in the paper in this Journal by Leonard and Mills, 1931.

1932 *d*. Insect conditions in Puerto Rico during the fiscal year July, 1931 thru June, 1932. Jour. Dept. Agr. P. R. **16**(2).

A number of species added to the list for the Island in various groups.

1932 *e*. Thrips injury to citrus and roses in Puerto Rico. Jour. Econ. Ent. **25**(4): 934–935.

The first identification of the blossom thrips of citrus—*Frankliniella insularis* Frank., *F. cubensis* Hood and *F. difficilis* Hood are the species involved; the one attacking roses is *F. insularis*.

1932 *f*. An early quarantine in Puerto Rico. Jour. Econ. Ent. **25**(4): 930–931.

Translation of a royal decree from Spain of August 10, 1815 against the entry of ants supposedly the bibijagua, *Atta insularis* Guer. into the Island.

1932 *g*. Notes from annual report on insect conditions in Porto Rico, July 1, 1930 thru June 30, 1931. Ins. Pest Surv. Bul. **11**(10): 682–685, February 1.

1932 *h*. Insect conditions in Porto Rico, October 1, 1931 to January 31, 1932. Ins. Pest Surv. Bul. **12**(1): 36–38, March 1.

1932 *i*. Insect conditions in Porto Rico during February and March, 1932. Ins. Pest Surv. Bul. **12**(3): 121–123, May 1.

1932 *j.* Insect conditions in Puerto Rico during April and May, 1932. Ins. Pest Surv. Bul. **12**(4): 185–186, June 1.

The title is in error since records for April only are included.

1932 *k.* Insect conditions in Puerto Rico from January 1 to June 30, 1932. Ins. Pest Surv. Bul. **12**(9): 405–408.

Brief notes on the status of a number of more or less injurous species.

1932 *l.* The cottony cushion scale in Puerto Rico. Jour. Econ. Ent. **25**(5): 1103–1107.

A brief account of the discovery, spread, foodplants and control of *Icerya purchasi* Mask. in Puerto Rico. Natural enemies in the Island are also discussed, most important of which is the Phorid fly, *Syneura cocciphila* Coq.; the introduction of the Australian lady beetle, *Rodolia cardinalis* Muls., is especially noted.

1933 *a.* Notes on the giant toad, *Bufo marinus* L., in Puerto Rico. Jour. Econ. Ent. **26**(1): 67–72.

General distribution, life-history and food-habits with special reference to Puerto Rico, and successful shipments of live toads to Honolulu from Puerto Rico are discussed.

1933 *b.* A Braconid parasite of a Coccinellid new to Puerto Rico. Jour. Econ. Ent. **26**(1): 294.

Brief note on the occurrence of *Homotylus terminalis*, Say, heavily parasitizing pupae of *Cycloneda sanguinea* L. predaceous on the yellow cane aphis, *Sipha flava* Fbs.

1933 *c.* Notes on insect conditions in Puerto Rico for the fiscal year, July 1931 thru June 1932. In press for the April number Jour. Dept. Agr. P. R. 17(2).

Leonard, M. D. and **Mills, A. S.** 1931 *a.* A preliminary report on the lima bean pod-borer and other legume pod-borers in Porto Rico. Jour. Econ. Ent. **24**(2): 466–473.

Notes on the distribution & food plants of *Maruca testulalis* Geyer, *Etiella zinckenella* Treit., *Fundella cistipennis* Dyar and *Brachyacma palpigera* Wlsm. and on parasites of two of these; among 5 other borers noted *Ancylostomia stercorea* Zell, was new to the Island.

1931 *b.* Observations on the bean lace-bug in Porto Rico. Jour. Dept. Agr. P. R. **15**(3): 309–323, 1 fig. 2 pls., July (September actual date of issue).

Distribution, economic importance, food-plants, description of stages and control of *Corythucha gossypii* Fab. with an annotated bibliography of 44 titles.

Leonard, M. D. and **Seín, Jr., F.** 1931. The papaya fruit fly in Puerto Rico. Jour. Econ. Ent. **24**: 331–332.

Results of a survey to determine the distribution of *Toxotrypana curvicauda* Gerst. in the Island.

1932. Observations on some factors which may affect the abundance of *Diatraea saccharalis* in Porto Rico. Proc. 4th Congress Int. Soc. Sugar Cane Techs., (Preprint Bul. No. **92**: 1–2), San Juan, P. R.

Léveillé, A. 1907. Études sur la famille des Temnochilides. Ann. Soc. Ent. France **76**: 401–402.

Temnochila portoricensis described as a new species from Puerto Rico.

Lewis, G. 1888. Biol. Cent. Am. Coleoptera. Histeridae. **2**(7): 208.

Epierus antillarum Marseul listed as occurring in Puerto Rico.

Linnaeus, Carolus. 1767. Systema Naturae. Ed. 12. **1**: 807.

The original description of *Empyreuma pugione* (as *Sphinx*) from St. Thomas. Dr. W. T. M. Forbes believes that since this has not been recorded from St. Thomas for 150 years the type specimen probably really came from Puerto Rico as the species is well known there.

Loew, H. 1851. Beschreibung einiger neuen Tipularia terricola. Linnea, **5**: 396–397 and 401–402. pl. 2. figs. 9–12.

Geranomyia rufescens (as *Aporosa*) and *Toxorhina fragilis* as new species from Puerto Rico.

López Domínguez, F. A. 1920. La preparación de la disolución arsenical para el exterminio de la garrapata. Est. Exp. Ins. P. R. Circ. **24**. 12 pp.

Directions for the preparation of the arsenical dip for the eradication of the cattle tick.

1927. Informe anual del director de la estación experimental insular, Río Piedras, 1925–26, 62 pp.

Notes on cane grubs, including suggested parasite introduction and the importation of the toad, *Bufo marinus* L., from Jamaica for their control; the sugar cane root-caterpillar (incorrectly called *Sufetula grumalis* Schaus); the banana root-weevil and several citrus insects, including notes on *Anastrepha fraterculus* which it is stated does not infest citrus in Puerto Rico.

1932. La Estación Experimental Insular, sus labores y resul-

tados alcanzados. El Agricultor Puertorriqueño **12**(5): 25–27 and 41–43, San Juan, March 15.

Brief account on p. 27 of the chief entomological accomplishments during the life of the Station.

López Tuero, Fernando. 1895. La caña de azúcar en Puerto Rico, su cultivo y enfermedad, Capítulo 4, enemigos de la caña y modo de combatirlos, pp. 63–74. Enfermedad de la caña de azúcar, pp. 105–123. Río Piedras, P. R.

Brief account of the injury and control of the more important sugar cane pests.

1896. Tratado de cultivos tropicales, pp. 1–272, 2nd ed., printed by the Boletín Mercantile in Puerto Rico.

A general treatise on various tropical crops in the discussion of several of which is included a section on diseases and insects as follows: p. 16, enemies of cotton, but no specific reference is made to Puerto Rico; pp. 87–88, coffee insects in Puerto Rico, including ants, June beetles and white grubs, the beetle known as the ''encelado'' or ''cucarachón'' and the Cossonus weevil which is undoubtedly *Lachnopus coffeae* Marshal, the changa, the ''piojillo'' and the ''cochinilla blanca'' and the ''cochinilla oscura;'' pp. 141–149, various sugar cane insects are discussed and control measures given for the most of them; p. 197, the grain weevil is mentioned as attacking corn, the kernels of which the larva eats out; pp. 205–206, the rhinoceros beetle is discussed as an enemy of coconuts; p. 232, white grub injury to bananas; pp. 251–252, discussion of several of the more important Antillean tobacco insects.

Luciano, José. 1922 *a*. Plagas de insectos dañinos al hogar y medios para combatirlos. Rev. Agr. P. R. **8**(1): 27–36.

Notes on cockroaches, ants, houseflies, crickets, silver fish and cloth moths and their control.

1922 *b*. Datos sobre la campaña del gusano rosado de la cápsula del algodón. Rev. Agr. P. R. **8**(3): 63–64.

Notes on the campaign against the cotton pink bollworm.

1927. La mosca mediterránea. El porqué debemos evitar la introducción de este insecto a nuestra isla. Rev. Agr. P. R. **18**(3): 143–144.

Brief general account as a basis of pointing out the necessity for the protective quarantine of the U. S. and Puerto Rico.

Ludlow, C. S. 1905. Mosquito notes—No. 4. Can. Ent. **39**: 385–388.

Aedes (*Taeniorhynchus*) *portoricensis* described as a *Culex* on page 386 from San Juan, P. R.

Lutz, A. and **da Costa Lima, A.** 1918. Contribuição para estudo das Tripaneidas (Moscas de frutas) brazileiras. Mem. Inst. Oswaldo Cruz **10**(1): 4–16, 2 pls.

In a general discussion of the Brazilian fruitflies or Trypetids is it stated that the most important species, *Anastrepha fraterculus* Weid., also occurs in Puerto Rico.

Lutz, F. E. 1915. List of Greater Antillean Spiders with notes on their distribution. Ann. N. Y. Acad. Sci. **26**: 71–148.

On pages 113–115 is a general account of the Puerto Rican spider fauna with a table showing the American distribution of Puerto Rican genera; P. R. records are scattered thru the paper.

Macquart, J. 1834. Histoire naturelle des insectes dipteres, 1, pp. 229 and 450.

Hermetia albitarsus Fab. described as a new species from Puerto Rico under the name *H. sexmaculata*; also *Psilopus portoricensis* as a new species from Puerto Rico.

1840. Dipteres exotiques nouveaux ou peu connus, 3, p. 121.

Brief description of *Psilopus portoricensis* Macq. In the "Supplement" to this work (1846) the male is recorded on p. 120.

Maklin, F. W. 1867. Monographie der Gattung Strongylium Kirby, Lacordaire und der damit zunachst verwandten Formen. Acta Soc. Sci. Fennicae **8**(1): 265.

S. pulvinatum described as a new species from Puerto Rico.

Malloch, J. R. 1913 *a*. A revision of the species of Agromyza Fallen and Cerodontha Rondani. (Diptera). Ann. Ent. Soc. Am. **6**(3): 324, 328.

Agromyza plumisita and *A. minima* described as new species from Puerto Rico.

1913 *b*. Descriptions of new species of American flies of the family Borboridae. Proc. U. S. Nat. Mus. **44**(1958): 361–372.

Limosina lugubrina, *L. rotundipennis* and *L. niveipennis* as new species from Puerto Rico.

1913 *c*. The genera of flies of the subfamily Botanobiinae with hind tibial spur. Proc. U. S. Nat. Mus. **46**(2024): 248–249.

Hippelates spicata as a new species from Puerto Rico.

1914. Description of a new species of Agromyza from Porto Rico. Proc. Wash. Ent. Soc. **16**(2) : 89–90, fig. 1.

Agromyza inaequalis as a new species from leaves of *Vigna repens* in Puerto Rico.

M. A. M. 1932. Sobre la mosca de las frutas. Bol. Agr. (Puerto Rico) **1**(29) : 3, February 27.

A brief note regarding *Anastrepha* in citrus.

Mann, Wm. M. 1920. Additions to the ant fauna of the West Indies and Central America. Bul. Am. Mus. Nat. Hist. 42, (Art. 8) : 428.

Solenopsis globularia F. Smith *desecheoensis* described as a new variety from Desecheo Island, P. R.

1931. Entomology.—A new ant from Porto Rico. Jour. Wash. Acad. Sci. 21(17) : 440–441, 1 fig.

Cerapachys (Syscia) seini described as a new species from soil about roots of sugar cane.

Mari, Mariano. 1931. Cómo combatir las queresas. Rev. Agr. (P. R. Dept. Agr.) **1**(7) : 3–4.

Brief directions for the control of scale insects.

Marlatt, C. L. 1903. Insecticidas importantes. Instrucciones para su preparación y uso. Dept. Interior P. R. Neg. Agr. y Minas Bol. Agr. 18, pp. 5–39. San Juan, December.

A translation of U. S. Farmers' Bul. 127, pp. 1–45, 1903 on Important Insecticides, directions for their preparation and use.

1908. New species of Diaspine scale insects. U. S. Bur. Ent. Tech. Bul. **16**(pt. 2) : 26–27, pl. 7, fig. 2.

Leucaspis indica as a new species from Florida and Puerto Rico.

1920. Report of the federal horticultural board [1919–20]. U. S. Dept. Agr., 29 pp.

Reference is made to a quarantine issued against cotton and cotton seed from Puerto Rico on account of the existance of *Eriophyes gossypii* Bks. there.

1928. Report [1927–28] of the federal horticultural board. U. S. Dept. Agr. 42 pp.

Euscepes batatae Waterh. is listed as having been intercepted in sweet potatoes from Puerto Rico.

Márquez, Nelson & Lizardi, Oscar. 1926. Resultados obtenidos

en la demostración número 90 sobre "represión del picle de la batata". Rev. Agr. P. R. **17**(5): 17. November.

Result of a demonstration in the control of the sweet potato weevil, *Cylas formicarius* Fab.

Marseul, S. A. de 1854. Essai momographique sur la famille des Histérides. Ann. Soc. Ent. France, Ser. 3, **2**: 671–707.

Epierus antillarum as a new species from Cuba, Puerto Rico and Santo Domingo.

Marshall, Guy A. K. 1922. Some injurious neotropical weevils (Curculionidae). Bul. Ent. Res. **13**(1): 59–78, pl. 2, fig. 4.

Five species and 1 new variety described from Puerto Rico.

Maskew, F. and **Strong, L. A.** 1920. Quarantine division. Reports September–December. 1920. Monthly Bul. Cal. Dept. Agr. **9**(12): 721–725.

On p. 726 *Lepidosaphes beckii* is listed as intercepted from Puerto Rico on grapefruit in October and on p. 734 on orange in December.

1925. Root knot on sugar cane in Porto Rico. Phytopathology 15(9): 559–563, 2 figs.

Symptoms and extent of injury are given and a suggestion for control.

Matz, Julius. 1920. Citrus and pineapple rots. Ins. Exp. Sta. P. R. Bul **24**: 12, 3 figs.

In discussing various rots it is stated that the puncturing of pineapples by mealybugs, *Pseudococcus bromeliae* (now identified as *P. brevipes*) is often responsible for the spread of disease.

May, D. W. 1906. Report on agricultural investigations in Porto Rico, 1905, pp. 1–21.

pp. 11–12, a note on control of cotton insects (*Alabama argillacea* bad during the year); p. 13, a note on *Heliothis obsoleta* on corn; pp. 21, a note on soaking cane seed in limewater for the control of Diatraea.

1910. Sugar cane in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Bul. **9**: 39. (Also a Spanish edition.)

The mole cricket and white grub are mentioned as injurious.

1926. Agricultural notes. P. R. (Mayagüez) Agr. Exp. Sta. Ext. Leaflet No. 26, 2 pp.

Includes a note regarding the introduction of the giant toad, *Bufo marinus* L., by the P. R. Agr. Exp. Sta. from Barbados in 1920; 60,

specimens brought in for the purpose of controlling such injurious insects as Lachnosterna spp., *Scapteriscus vicinus* and cockroaches.

1927. Germinating sugar cane. P. R. (Mayagüez) Agr. Exp. Sta. Notes No. 38, 2 pp., April 27.

Report on experiments in soaking sugar cane sets in various solutions for the control of insect pests, especially *Diatraea saccharalis* F.

1930. Report of the Director. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1929, p. 4, 1 fig.

Brief note on the effective establishment and wide distribution of the imported toad, *Bufo marinus* L., and its benefits in reducing the numbers of certain injurious insects. The introduction of the frog, *Leptodactylus pentadactylus* from Dominica, B.W.I., for the same purpose and also possibly for food is also mentioned.

McAtee, W. L. 1932. A new neotropical genus of Eupteryginae (Homoptera) from Puerto Rico. Jour. Dept. Agr. P. R. **16**(2): 119–120, 1 fig.

Hybla maculata described from mamey from Barceloneta and Pt. Cangrejos.

McClelland, T. B. 1931. The relation of the Porto Rico Agricultural Experiment Station (Mayagüez), P. R., to the agriculture of Porto Rico.—1904–1930. Agr. Notes of the P. R. Agr. Exp. Sta. No. 54, 3 pp. (Also published in the Porto Rico Progress, San Juan, P. R., shortly after.)

On p. 3 is a note regarding the introduction of the giant toad, *Bufo marinus* L., and its subsequent beneficial effect by its reduction of such insects as mole crickets, white grubs, ants and cockroaches.

McClelland, T. B. and **Tucker, C. M.** 1929. The green scale, *Coccus viridis*, a new pest in coffee and citrus. Agr. Notes of the P. R. (Mayagüez) Agr. Exp. Sta. No. 48, 2 pp. Also a Spanish edition.

Brief account of the very recent discovery of this scale in Puerto Rico, with general and local distribution and food-plants and control.

McKinley, Earl B. 1929. The salivary gland poison of *Aedes aegypti*. Proc. Soc. Exp. Biol. and Med. **26**: 806–809.

Results of attempts to immunize susceptible individuals to mosquito bites conducted in Puerto Rico.

Medina, Vicente. 1931. El control de enfermedades y plagas en los semilleros y viveros de café. Bol. Agr. (P. R. Dept. Agr.) **1**(7): 2–3.

Brief account, with control, of the coffee leaf-miner, *Leucoptera coffeella* Stainton.

Melander, A. L. 1927. Diptera. Empididae. Genera Insectorum, Fasc. 185, p. 32.

Euhybos spiniger as a new species from Utuado, P. R., Jan. 1899 (Aug. Busck) in U.S.N.M. Curran thinks this may be the same as his *E. spinosus*.

Menéndez Ramos, R. 1923. El pulgón amarillo de la caña. Rev. Agr. P. R. **11**(4): 23–27, 1 fig.

Brief general account of the damage and control of the yellow cane aphis, *Sipha flava* Fbs.

1924. El "*Melinitis minutiflora*" y la garrapata. Rev. Agr. P. R. **12**(4): 219–223, 2 figs.

Trials show that molasses grass does not destroy cattle ticks, *Boophilus* (*Margaropus*) *annulatus australis* Fuller, but repels them.

1926. Cómo hemos combatido el gusano agrimensor de la caña en Humacao. Rev. Agr. P. R. **16**(1): 9–11.

Merrill, Geo. B. 1915. Progress report on investigations relative to the horn-fly. Third Rept. Bd. Comm. Agr. P. R., 1913–1914, pp. 53–55.

A brief note on the introduction of predaceous beetles from Texas, Santo Domingo and Illinois.

1916. Report of the tobacco insect investigations. Fourth Rept. Bd. Comm. Agr. P. R., 1914–1915, pp. 50–52.

1923. Scale insects of Florida. Fla. State Plant Bd. Quart. Bul. 7(4): 177–298, figs. 16–116.

A number of the many species described and figured are mentioned as also occurring in Puerto Rico.

Mills, A. S. and **Leonard, M. D.** 1931. The eggs of the lima bean pod-borer in Porto Rico—Maruca testulalis Geyer (Lepid.: Pyralidae). Jour. Econ. Ent. **24**(3): 763.

First note on the location and description of the eggs of this widely distributed species.

Molinary Sales, E. 1924. Demostración No. 8. Extirpación del gusano agrimensor (*Mocis remigia repanda*) que ataca las hojas de la caña. Rev. Agr. P. R. **13**(6): 385–387.

In the case of an infestation of sugar cane by this caterpillar dusting with arsenate of lead and lime is recommended.

Montgomery, J. H. and **Bragdon, K. E.** 1919. Quarantine Department. Qtrly. Bul. Fla. State Plant Bd. **3**(2) : 110–112.

Euscepes batatae is reported as having been intercepted in sweet potatoes received from Puerto Rico into Florida during the quarter ending December 31st, 1918.

* **Moore, E. L.** 1910. Insect pests and their extermination. The P. R. Hort. News. pp. 134, 143, 144, September. (Ref. from Pedreira.)

Discusses the changa or West Indian mole cricket.

More, J. D. 1921 *a*. La vaquita o piche de la batata. Est. Exp. Ins. P. R. Circ. **34**, 7 pp. 1 pl. colored.

Brief general account of the sweet potato weevil and its control in Puerto Rico.

1921 *b*. Las pulgas del tabaco. Est. Exp. Ins. Circ. **50**, 8 pp.

Brief general account of the tobacco flea-beetles in Puerto Rico and their control.

1921 *c*. Insectos predominantes durante el mes. Rev. Agr. P. R. **5**(7) : 33–36.

Notes on damage by and suggestions for control of the changa and the sweet potato weevil.

1921 *d*. Instrucciones concernientes al gusano rosado del algodón. Rev. Agr. P. R. **6**(5) : 21–26.

Notes concerning the life-history and habits of the cotton pink bollworm in Puerto Rico, for the information of cotton growers.

1923. Insects, fish and other fauna of Porto Rico. The Book of Porto Rico, pp. 54–64, several figs. San Juan.

A very brief account of the more important injurious insects of the Island in both Spanish and English.

Morgan, A. C. 1925. A new genus, a new subgenus and seven new species of Thysanoptera from Puerto Rico. Florida Entomologist **9**(1) : 1–9.

Ceroyothrips striatus n. gen. and sp.; *Sericothrips portoricensis* and *Anaphothrips bicolor* n. spp.; *Lissothrips* (*Prolissothrips*) *stratulus* n. subgen and sp.; *Gastrothrips fuscicauda*, *G. anolis* and *Diceratothrips wolcotti* n. spp.

Morrison, Harold. 1932. On some trophobiotic Coccidae from British Guiana. Psyche **29**(4) : 145–148, pl. 6, figs. 20–31.

Akermes secretus new species from Puerto Rico [=*Cryptostigma* (*Pseudophillipia*) *inquilina* (Newstead) Ferris].

Möschler, H. B. 1890. Die Lepidopteren-Fauna der Insel Portorico. Abhandlungen Senkenbergischen Naturforschenden Gesellschaft **16**, Heft 1, pp. 69–360, 1 pl.

Catalog of the Lepidoptera of the Island based on the same material as Gundlach's paper; many new species are described.

Moser, J. 1918. Neue Arten der Gattungen *Lachnosterna* Hope und *Phytalus* Er. (Col.). Stett. Ent. Zeitg. **79**: 19–74.

Phyllophaga (*Lachnosterna*) *insulicola*, p. 61 and *P. portoricensis* (Chevrolat in lit.), p. 62 described as new species from Puerto Rico.

Muesebeck, C. F. W. 1921. A revision of the North American species of ichneumon-flies belonging to the genus Apanteles. Proc. U. S. Nat. Mus. **58**: (2349): 558–559.

Apanteles prenidis new species from Pureto Rico reared from *Prenes ares* Felder.

Muir, F. 1918. Homoptera notes II. Proc. Hawaiian Ent. Soc. **3**(5): 414–429.

Cyclokara sordidulum as a new species p. 416, and *Otiocerus schonherri* Stal p. 420, recorded from Puerto Rico (Derbidae): *Cayops occidentalis* and *Punana puertoricensis*, p. 425 as new species and *Neomalaxa flava* as a new genus and species, p. 426 (*Delphacidae*) from Puerto Rico.

* 1922. Direct and indirect injury to plants by insects. Hawaiian Planters' record **2**: 65–66. (Abs. in Rev. Appl. Ent. **10**: 347.)

Sugar cane mosaic not so serious in Hawaii as in Puerto Rico due possibly to the presence in the latter place of insect vectors which carry the disease directly from unhealthy to healthy cane whereas in Hawaii it is carried by occasional visitors to the plants.

1924. New and little known Fulgorids from the West Indes (Homoptera). Proc. Hawaiian Ent. Soc. for 1923 **5**(3): 461–472, pl. XII.

Ormenis pseudomarginata (Flattidae), p. 469–470; *Acanalonia brevifrons* (Acanaloniidae), p. 467; *Cubana tortriciformis* (Cixiidae), p. 461; *Cedusa wolcottii* (Derbidae), p. 462; *Dysimia* (new genus) *maculata* (Derbidae), pp. 462–464; *Parahydriena* (new genus) *hyalina* (Derbidae), pp. 464–465; *Colpoptera brunneus* (Issidae), pp. 465–466 and *C. maculifrons* (Issidae), p. 466, all as new species from Puerto Rico.

Muir, F. and **Gifford, W. M.** 1924. Studies in North American

Delphacidae. Hawaiian Sugar Planters' Exp. Sta. Bul. **15** (Ent. Ser., pp. 9, 17).

Neomalaxa flava Muir recorded as occurring in Puerto Rico and *Nilaparvata wolcotti* described by Muir as new species from Puerto Rico.

Mutchler, A. J. 1923 *a*. Notes on West Indian Lycidae and Lampyridae (Coleoptera) with descriptions of new forms. Am. Mus. Novitates No. 60, 13 pp., 1 fig. March 15.

Callopisma borencona as a new species from several localities (Lycidae) on p. 9 and *Pyractomena galeata* E. Oliver listed from Puerto Rico.

1932 *b*. Notes on West Indian Lampyridae and Cantharidae (Coleoptera) with descriptions of new forms. Am. Mus. Novitates No. 63, 9 pp., 1 fig., March 29.

Photinus heterodoxus L. & M., *P. dubiosus* L. & M., *P. vittatus* G. A. Oliv., and *Tytthonyx discolor* L. & M. listed from Puerto Rico with notes.

Myers, J. G. 1931 *a*. A preliminary report on an investigation into the biological control of West Indian insect pests. Empire Marketing Board 42: 53–54, 78, London.

Brief mention of the status of several of the more important insect pests of Puerto Rico.

1931 *b*. Descriptions and records of parasitic Hymenoptera from British Guiana and the West Indies. Bul. Ent. Res. **22**: 267–277, 3 figs.

Microdus stigmaterus Cress., p. 274, mentioned as having been artificially introduced into Puerto Rico by Box.

Nesbit, D. M. 1903. La batata. Dept. Int. P. R. Neg. Agr. y Minas Bol. Agr. 16, pp. 33–34.

Brief general account of the most important classes of insects injurious to the potato in this Spanish translation of U. S. Farmers' Bul. 129.

Nolla, J. A. B. 1924. Resultados de la demonstración No. 20 sobre el control de la changa en un semillero de cebollas. Rev. Agr. P. R. **12**(3): 202.

1929 *a*. Acrostalagmus aphidum Oud. and aphid control. Jour. Dept. Agr. P. R. **13**(2): 59–72.

Excellent results by spraying liquid cultures of this fungus in the

control of 7 determined species of common aphids and 2 undetermined species in Puerto Rico.

1929 *b*. Un hongo parasitario de los áphidos. Rev. Agr. P. R. **23** (5): 196–197.

Brief popular version of the above paper.

1929 *c*. El Acrostalagmus aphidum Oud. en la lucha contra los áfidos. Mem. Soc. Esp. Hist. Nat. **15**: 9–12. 1 fig., 1 pl.

Much the same information as in 1929 a.

Notman, Howard. 1929. New species of *Palaminus* from the West Indies, together with a synoptic review of the genus Am. Mus. Novitates No. 386, 17 pp., November 27.

P. lengi, parvipennis, bifids, scitulus, pusillus, grandicollis, procerus as new species and *P. insularis* Cameron listed from Puerto Rico.

Ochs, Geo. 1924. On the West Indian Gyrinidae and a new species of Gyretes from Northern Brazil. Am. Mus. Novitates No. 125, 8 pp., July 24.

Dinutus carolinus LeConte, *D. mutchleri* as new species and *D. longimanus* (Oliv) *portoricensis* as new subspecies from Puerto Rico; *Gyrinus rugifer* Regimbart and *Dinutus metallicus* Aubé listed from Puerto Rico with notes.

[**Olivier, A. G.** 1790. Entomologie **2** No. 28. p. 23. pl. 3. fig. 20.

Photinus vittatus is described as a new species from Santo Domingo only. Wolcott in his "List" on p. 82 states that the types were from Puerto Rico also. The species is, however, widely distributed in Puerto Rico].

1807. Entomologie **5**, No. 83, p. 145.

Baris torquatus (as *Rhynchaenus*) and *R. militaris* (probably now in *Pseudonus*) as new species from Puerto Rico.

1808. Entomologie **6**, No. 93, pp. 635–636.

Galerucella obliterata as a new species from Puerto Rico.

Olivier, E. 1899. Revision des coléopteres Lampyrides des Antilles et description des espéces nouvelles. Bul. Soc. Ent. France **24**: 87–92.

Lecontea galeata (as *Pyractomena*) as a new species from Puerto Rico on p. 91.

1912. Contribution a la faune entomologique des Antilles.

Lampyrides. Rev. Sci. du Bourbonais et du centre de la France, **25**: 19 and 33.

Callopisma dimidiatipennis Oliv. p. 19 and *Photinus triangularis* Oliv. p. 33 listed from Puerto Rico.

1912 *b*. Lampyrides faisant partie des collections du musée de Washington. Ann. Soc. Ent. Belgique **56**: 25.

Photinus triangularis as a new species from Puerto Rico

Osborn, Herbert. 1928. Neotropical Homoptera of the Carnegie Museum. Part 6. Report on the subfamily Typhlocybinae with descriptions of new species. Ann. Carnegie Mus. **18**(2): 253–298.

Protolebra bicincta, p. 259 and *P. pallida*, p. 260 as new species and *P. similis* Baker pp. 263–264 listed from Puerto Rico.

1929. Notes on Porto Rican Homoptera. Jour. Dept. Agr. P. R. **13**(3): 81–82.

Records a number of species mostly based upon a collecting trip to the Island during the winter of 1928–1929; 7 species of leafhoppers are described as new; general discussion of ecology and distribution.

Osten Sacken, C. R. 1887. Studies on Tipulidae, Part 2. Berl. Ent. Zeitschr. **31**: 184.

Rhamphidia albitarsus as a new species from Puerto Rico.

Osuna, Pedro. 1929. Medios para combatir los insectos en las hortalizas. Rev. Agr. P. R. **23**(2): 82 and 95.

Brief practical directions for the control of vegetable insects.

Pagenstecher, Arnold. 1907. Die Lepidopteren Fauna der Antillen. Jarb. Nassauische Ver. Naturbunde **60**: 91–92. Weisbaden.

On p. 97 is a brief geographical summary of Puerto Rican Lepidoptera with references to several of the more important papers on the subject.

Parker, R. R. 1914. Sarcophagidae of New England: males of the genera Ravinia and Boettcheria.

Sarcophaga quadrisetosa Coq. (as *Ravinia*) listed as occurring in Puerto Rico.

Pastor Rodríguez, Juan. 1929. El cultivo del algodón Sea Island. Rev. Agr. P. R. **22**(10): 157–158 and 172.

Notes on the injury and control of the more important insects of Sea Island cotton in Puerto Rico are included.

1931 *a*. Alarmante irrupción de la oruga rosada del algodón en el distrito sur. Rev. Agr. P. R. **26**(9): 174, 176.

Brief account of the outbreak of the pink bollworm of cotton during the previous season in the South coast of the Island.

1931 *b*. Alrededor de la oruga rosada (*P. gossypiella*). Bol. Agr. (P. R. Dept. Agr.) **1**(6): 2-3.

Brief account of the increased infestation of the pink bollworm in the south coast during the past season with a sketch of the life-history and outline of control measures.

1932. Porto Rico moves forward in cotton. Cotton Trade Journal, International Edition, 1932, pp. 91-93, 1 map, 3 figs., 2 tables. New Orleans, La.

On p. 93 is a brief discussion of the status of the more important insect pests in Puerto Rico: the pink bollworm and the cotton leaf-worm; the absence of the boll weevil is noted.

Altho this article bears no authorship it was written by Mr. Pastor Rodríguez.

Pedreira, Antonio S. 1932. Bibliografía Puertorriqueña (1493-1930). Monografías de la Universidad de Puerto Rico. Serie A. Estudios Hispánicos. Núm. 1. Madrid, XXXII 707 pp.

Contains about 200 references to articles on Puerto Rican entomology, about 175 of which are under the heading of "Entomología económica" and the remainder scattered thru several other sections.

Pemberton, C. E. and **Leonard, M. D.** 1932. Entomology at the Fourth Congress of the International Society of Sugar Cane Technologists in Porto Rico. Jour. Econ. Ent. **25**(3): 732-733. Also under same title in Ent. News **43**(7): 195-196.

Brief note giving names of entomologists in attendance and general subjects of papers presented at the Congress.

Pérez Torres, Manuel. 1922. Fiebre tejana. Rev. Agr. P. R. **22**(5): 220-221, 225, 1 fig.

A general discussion of Texas fever with brief directions for its control by ridding the cattle of ticks.

Pergande, T. and **Cockerell, T. D. A.** 1900. List of the Coccidae collected by Mr. A. Busck in Porto Rico, 1899. U. S. Dept. Agr. Div. Ent. Bul. **22**. New Series, pp. 92-93.

Twenty-three listed, with dates of collection and food-plants.

Petrunkevitch, Alex. 1911. A synoptic index-catalogue of spiders of North Central and South America with all adjacent

islands, Greenland, Bermuda, West Indies, Tierra del Fuego, Galápagos, etc. Bul. Am. Mus. Nat. Hist. **29**: 1809.

All spiders recorded to date from Puerto Rico are listed.

1926. Tarantula versus tarantula-hawk: a study in instinct. Jour. Exp. Zool. **45**(2): 367–393, 2 pls.

A contribution from the University of Puerto Rico in which the attack of the tarantula-hawk, *Pepsis marginata* P. de B. upon *Cyrtophilus portoricae* Chamb, under observation cage conditions at Río Piedras, P. R., is described in detail.

1929. The spiders of Porto Rico. Part One. Trans. Conn. Acad. Arts and Sci. **30**: 1–158, 150 figs.

1930 *a*. The spiders of Porto Rico. Part Two. Trans. Conn. Acad. Arts and Sci. **30**: 159–355, 240 figs.

1930 *b*. The spiders of Porto Rico. Part Three. Trans. Conn. Acad. Arts and Sci. **31**: 1–191, 168 figs.

One hundred seventy-four species are described in detail in the above 3 parts, 72 of which are described as new.

Phillips, E. F. 1914. Porto Rican beekeeping. P. R. (Mayagüez) Agr. Exp. Sta. Bul. **15**, 24 pp., 2 pls. Also a Spanish edition, 28 pp., 1915.

Pierce, W. Dwight. 1914. Descriptions of two new species of Strepsiptera parasitic on sugar cane insects. Proc. Ent. Wash. **16**(3): 126–129.

Stenocranophilus quadratus as a new genus and species reared from *Saccharosydne saccharivora* Westw. in Puerto Rico.

1915. Some sugar-cane root-boring weevils of the West Indes. Jour. Agr. Res. **4**(3): 255–264, 4 pls.

Description of and notes on *Diaprepes famelicus* (not in P. R.) Oliver and *D. spengleri* & its varieties, of which *D. s. spengleri, comma* and *abbreviatus* are stated to occur in Puerto Rico.

1917. A Manual of dangerous insects likely to be introduced into the United States through importations. U. S. Dept. Agr. Office of Sec'y. Contrib. from Bur. Ent. and Fed. Hort. Bd., Aug. 15.

An occasional specific reference to Puerto Rico.

1918. Weevils which affect Irish potato, sweet potato and yam. Jour. Agr. Res. **12**(9): 608, pl. 32, figs. C, D.

Records having specimens of *Euscepes batatae* from Mayagüez, P. R., which were injuring sweet potatoes.

Quaintance, A. L. 1900. Contributions toward a monograph of the American Aleurodidae. U. S. Bur. Ent. Tech. Bul. **8**: 43-47, pl. 6, figs., 63-67.

Aleurodicus (Metaleurodicus) minimus as a new species from Puerto Rico.

Quaintance, A. L. and **Baker, A. C.** 1915. Classification of the Aleyrodidae, Parts 1 and 2. U. S. Bur. Ent. Tech. Bul **27**: 1-114 pp., many pls. & figs.

I fail to find *Dialeurodes buscki* as a new species from Puerto Rico but *Aleurodicus minimus* Quain. is redescribed in the new subgenus *Metaleurodicus* on p. 77 and *Leonardius lahillei* Leonardi is redescribed on p. 33, both from Puerto Rico.

Quedenfeldt, G. 1886. Neue und seltnere Käfer von Portorico. Berl. Ent. Zeits. **30**(1): 119-128.

Ten new species and 1 new variety, including 1 new genus described from Puerto Rico.

Quintanilla, Guillermo. 1896. Enfermedad de los cafetales en Adjuntas, la plaga de la vaquita. La Reforma Agrícola (Organo de la Asociación de Agricultores de Puerto Rico), year 3, No. 12, pp. 217-224. November.

Records an inspection trip to Adjuntas in April 1895 to investigate an outbreak of a weevil on coffee, which according to local growers had been doing more or less damage there for 14 years; it is stated that the adult injures the leaves, green shoots, buds, flowers and fruit of the coffee trees; a sketchy description of some length is given of the adult and the author judges that it belongs to the genus Cossonus (he spells it Cossonus) of the Curculionidae; larvae and pupae were not found; it is suggested that the soil be put in better condition for coffee production and after sufficient experimentation that control measures should be used directly against the adult weevils; it is reported that growers had tried spraying with petroleum, fenic acid, and with hypochlorite of lime with very contradictory results.

Altho Quintanilla's description of the adult weevil is very general, neither length nor color even being mentioned, there seems little doubt that the insect under discussion is *Lachnopus coffeae* Marshall, or possibly of course var. *montanus Marshall,* both of which were not described until 1922. If so Quintanilla's is the earliest published account of the insect.

Rehn, James A. G. 1903*a*. Notes on West Indian Orthoptera,

with a list of the species known from the Island of Porto Rico. Trans. Am. Ent. Soc. **29**: 129–136.

Many species listed, including *Apterigida buscki* (Blattidae), p. 129 and *Lamponius portoricensis* (Phasdimae), p. 132 as new species from Puerto Rico. *Neoblatella adspersicollis* Stal.

1903 *b*. Studies in American Blattidae. Trans. Am. Ent. Soc. 29: 268–285.

Blatella azteca S. & Z., p. 268, *Periplaneta americana* L., p. 280 and *Panchlora hyalina* Sauss., p. 285 listed from the Island and *Pelmatosilpha coriacea*, pp. 278–279 as a new species from Puerto Rico.

1904. Studies in the orthopterous family Phasmidae. Proc. Acad. Nat. Sci. Phila. **56**: 68–69.

Apiopus achalus (Phasmidae) described from Puerto Rico as a new species.

1906. The orthoptera of the Bahamas. Bul. Am. Mus. Nat. Hist. **22** (Art. 5): 110, May 23.

A foot note states "This is the species recorded by me as *B. punctulata* from Puerto Rico (Trans. Amer. Ent. Soc. xxix p. 130) and *B. azteca* from Puerto Rico and Jamaica (Ibid., xxix, p. 268)." The species referred to is *Neoblatella adspersicollis* Stal.

1910. On some Orthoptera from Porto Rico, Culebra and Vieques Islands. Bul. Am. Mus. Nat. Hist. **28** (Art. 7): 73–77.

Epilampra wheeleri (Blattidae) as a new species from Puerto Rico, pp. 73–74.

Rehn, J. A. G. and **Hebard, Morgan.** 1927. The Orthoptera of the West Indies. Number 1. Blattidae. Bul. Am. Mus. Nat. Hist. **54** (Art. 1): 1–320, 25 pls.

Thirty species from Puerto Rico treated.

Reitter, Edm. 1875. Die Sud—und Mittel—Americanischen Arten der Gattung Tenebroides Pill. et Mitterp. Verh. Nat. Ver. Brünn (for 1874) **13**: 74.

Tenebroides punctulatus listed from Puerto Rico.

1878. Neue Colydiidae des Berliner Museums. Deutsche Ent. Zeitschr. **22** (1): 123.

Penthelispa aquicolle as a new species from Puerto Rico.

1883. Beitrag zur Kentniss der Clavigeriden, Pselaphiden und

Scydmaeniden von Westindien. Deutsche Ent. Zeitschr. **27** (1): 33–46.

Trimiopsis ventricosa on p. 39, *parmata* on p. 40 and *eggersi* on p. 38 as new species from St. Thomas and Puerto Rico.

Richardson Kuntz, Pedro. 1932. Censo de las variedades de caña de azúcar sembradas en Puerto Rico correspondiente a la cosecha de 1931–32. Est. Exp. Ins. Circ. **98**: 14–16.

It is stated that, in the author's opinion, *Diatraea saccharalis* Fab. causes at the present time five times as much damage in the South and East Coast districts as the three most important cane diseases combined, namely mosaic, gummosis and Pokka Boeng. *Phyllophaga* spp and *Scapteriscus vicinus* are also mentioned as being injurious to cane but of secondary importance to the moth borer.

Riley, C. V. 1894. The insects occurring in the foreign exhibits of the world's Columbian Exposition. Insect Life **6**(3): 218.

Cathartus advena Waltl. listed as occurring in Puerto Rico.

Riollano, Arturo. 1931. Rehabilitación agrícola de Vieques. Informe del trabajo realizado. Rev. Agr. P. R. **26**(9): 108–116. March.

Includes notes on several injurious insects including the cotton leafworm, pink bollworm and the cowpea stalk and pod borer, *Fundella cistipennis*.

Ritchie, A. H. * 1917. Report of the government entomologist for the year 1916 1917. Suppl. to the Jamaica Gazette, Kingston, **40**(4): 92 97. (Abs. in Rev. Appl. Ent. **5**: 429.)

In discussing *Stenocranus saccharivorus* Westw. as a cane pest mention is made that parasites are an effective check in Puerto Rico, including a Mymarid, a Dryinid and a Strepsipteron.

* 1918. Annual report of entomologist. Ann. Rept. Jamaica Dept. Agr. for year ended 31st March, 1918, pp. 34–40. (Abs. in Rev. Appl. Ent. **7**: 56.)

In discussing *Euscepes porcellus* Boh. mention is made that it also occurs in Puerto Rico.

Rivera, Alfonso. 1922. Enfermedades de la piel en el ganado. Ins. Exp. Sta. P. R. Circ. **58**: 1–9.

Notes on the various skin parasites found on cattle, pigs, sheep and goats, with symptoms and remedies; the tick, *Ixodes ricinus* and mange mites are included.

Rivera, Eugenio M. 1927. Informe sobre el trabajo de es-

tudios del gorgojo del ñame del banano por el personal de campo destacado en Utuado, Adjuntas y Jayuya. Rev. Agr. P. R. **19**(2): 59–62.

Description of a survey to determine the presence of the banana root-weevil in three districts in the Island.

von Roeder, Víctor. 1885. Diptera von der Insel Porto Rico, erhalten durch Herrn Consul Krug in Berlin. Stett. Ent. Zeitung **46**: 337–349.

Several new species described; also other records.

Rohwer, S. A. 1915. Descriptions of new species of Hymenoptera. Proc. U. S. Nat. Mus. **49**: (2105): 205–249.

The following are described as new from Puerto Rico: *Elis xanthonotus*, p. 234; *Nysson (Bathystegus) basirufus*, p. 247; *Campsomeres (Campsomeris) pyrura*, p. 235; *Batozonus hookeri*, p. 237; *Psen (Mimesa) modesta*, p. 244; *Cerceris margaretella*, p. 248.

1927. Some Scoliid wasps from Tropical America. Jour. Wash. Acad. Sci. **17**(6): 150–155.

Includes a note on *Campsomeris hesterae* n. sp. which has been imported from Venezuela into Puerto Rico where it has oviposited on larvae of *Lachnosterna portoricensis* Smyth.

Root, F. M. 1922. Notes on mosquitoes and other blood-sucking flies from Porto Rico. Am. Jour. Hygiene **2**(4): 394–405, 5 figs.

An annotated list of all blood-sucking Diptera recorded to-date from the Island; 15 mosquitoes, of which *Culex (Choeropora) borenqueni* is described as new, are listed and the larvae of several are desribed; *Chrysops variegatus* DeG. (as *costatus* Fab.) and *Stomoxys calcitrans* are also listed.

Rosenfeld, A. H. 1925 *a*. The food of Porto Rican lizards. Jour. Econ. Ent. **18**(2): 422–423.

A note on the small lizard, *Anolis cristatelus* D. & B. attacking a moth of *Protoparce sexta* Joh., var. *jamaicensis* Butler about the same length of body as itself.

1925 *b*. Why not Trap-Crops that Entrap? Jour. Ec. Ent. **18**(4): 639–640.

Experiment on *Melinis muistiflora* as a tick-deterrent.

Rothschild, W. 1912. New Syntomidae. Novitates Zool. **19**(2). 155.

Describes *Empyreuma sanguinea portoricensis* as a new race from

Puerto Rico. Dr. W. T. M. Forbes considers this as merely typical *E. pugione* L.

Rothschild, W. and **Jordan, K.** 1903. A revision of the lepidopterous family Sphingidae. Novitates Zool. 9, Suppl., 972 pp., 67 pls.

A world revision of the family including all known locality records, many of which are from Puerto Rico.

Russell, H. M. 1912. The red-banded thrips. U. S. Bur. Ent. Bul. 99, Pt. 2, p. 17.

Foot note recording *Mesothrips ficorum* Marchal (= *Liothrips bakeri* Crawf.) on Ficus from Puerto Rico.

Saavedra, E. F. 1929. La oruga rosada de la cápsula del algodón en Puerto Rico. Rev. Agr. P. R. **23**(5): 207 and 216.

Brief popular account of the pink bollworm with control measures.

Sasscer, E. R. 1920. Important foreign insect pests collected on imported nursery stock in 1919. Jour. Econ. Ent. **13**(2): 184.

Lists *Targionia sacchari* Ckll. on sugar cane and *Pseudococcus crotonis* Green on orchid, both from Puerto Rico.

1921. Important insects collected on imported nursery stock in 1920. Jour. Econ. Ent. **14**(4): 354.

Records *Cylas formicarius* in sweet potato tubers and *Euscepes batatae* in yams arriving in the U. S. from Puerto Rico.

Saussure, H. 1859. Orthoptera Nova Americana (diagnoses preliminares). Rev. et Mag. Zool., 2nd Ser., **9**: 62–63.

Phibalosoma ceratocephalum Gray described as a new species from Puerto Rico as *Acanthoderus (Xylodus) adumbratus*.

1868. Phasmidarum novarum species non nullae. Rev. et Mag. Zool., (Ser. 2) **20**: 65.

Dyme (Bacteria) yersiniana as a new species from Puerto Rico.

1878. Mélanges orthoptérologiques. Fasc. **6**, 702–703; 747–748, pl. 18, fig. 64, 1 and 2.

On pp. 747–748 *Laurepa (Apithes) krugii* (Gryllidae) is described as a new species from Cuba, not Puerto Rico; on pp. 702–703 *Diatripus sibilans* is described as a new species from Puerto Rico.

[1893. Orthoptera in Biol. Centr. Am. **1**: 85.

Plecoptera krugi (Blattidae) as a new species from Cuba. (Wolcott in his "List" says the type is from Puerto Rico)].

1897. Orthoptera. Biol. Centr. Am. **1**: 276–277.

Orocharis vaginalis and *O. terebrans* (Gryllidae) as new species from Puerto Rico.

Schaufuss, L. W. 1882. Coléopteres aveugles de la famille des Colydidae. Ann. Soc. Ent. France, (Ser. 6) **2**: 46–48.

Cryptozoon nitidicollis as a new genus and species from Puerto Rico.

Seely, R. M. 1928. Revision of the spider genus Tetragnatha. N. Y. State Mus. Bul. **278**, pp. 106 and 133, pl. 1, figs. 1–4 and pl. 3, figs. 40–43.

T. antilliana Simon, p. 106 recorded on the authority of Banks (1901) and *T. pallescens* Cambridge p. 133 recorded from Puerto Rico at Toa Baja, Garb collector.

Seín Jr., Francisco. 1923 *a*. Cucarachas. Est. Exp. Ins. Circ. **64**: 1–12.

A discussion of the injurious cockroaches in Puerto Rico and their control.

1923 *b*. Las abejas en los cafetales. Est. Exp. Ins. Circ. 79: 1–6.

Observations to show that beekeeping is not injurious to the setting of berries in the coffee farms, but rather that the bees are beneficial.

1923 *c*. El gorgojo del ñame del guineo. Est. Exp. Ins. Circ. **82**: 1–7, 2 figs.

Brief general account of the banana rootweevil in Puerto Rico with control measures.

1926. La oruga de la raíz de la caña. Un insecto que no se sabía existiera en Puerto Rico y que causa mucho daño. Rev. Agr. P. R. **17**(2–3): 17.

Notes on the sugar cane root-caterpillar, *Perforadix sacchari* Sein in Puerto Rico.

1927. El sapo. Rev. Agr. P. R. **19**(5): 238–240.

Notes on the imported toad, *Bufo marinus* L., in Puerto Rico.

1928. Sericultura Rev. Agr. P. R. **20**(2): 51–53.

Brief general popular account of the silk industry and remarks on its attempted initiation in Puerto Rico.

1929 *a*. Report of the division of entomology. Ann. Rept. Ins. Exp. Sta. P. R. for 1927–1928, pp. 89–98.

Altho no authorship is assigned in this report it was prepared by Mr. Seín. It includes notes on sugar cane root insects and mosaic transmission, *Anastrepha* does not attack citrus, banana root-weevil and on failure of *Ipobracon grenadensis* to become established.

1929 *b*. El gorgojo del ñame del guineo en Puerto Rico. El Mundo, San Juan, P. R., October, 6, p. 15, 4 figs.

A general account of the banana root-weevil in Puerto Rico including control measures outlined in detail.

1929 *c*. Nuevas cosechas, nuevas plagas. Rev. Agr. P. R. **23** (2) : 84–86.

A note on the potato tuber moth (*Phthorimaea operculella* Zell.) attacking Irish potatoes for the first time in Puerto Rico.

1929 *d*. Una invasión de mariposas. Rev. Agr. P. R. **22**(10) : 169–170.

Notes on a large migration of *Anosia plexippus* L. in Puerto Rico.

1930 *a*. A new mechanical method for artificially transmitting sugar-cane mosaic. Jour. Dept. Agr. P. R. **14**(2) : 49–68.

1930 *b*. The sugar cane root caterpillar and other new root pests in Puerto Rico. Jour. Dept. Agr. P. R. **14**(3) : 167–191, 10 pls.

Complete account of *Perforadix sacchari* Seín (Pyralididae, Endotrichinae) new genus and species in Puerto Rico, including descriptions of all the stages and suggestions for lessening the injury. A Symphilid, *Hanseniella* sp., two bristle-tails, *Nicoletia* sp. and *Lepisma* sp., a sow-bug, *Philoscia culebrae* Moore, white grubs, nematodes, the larvae of *Diaprepes spengleri* and a mite are all discussed as to their relation to root injuries to sugar cane in Puerto Rico.

1930 *c*. Nuevo método de transmitir el matizado y su aplicación práctica. Rev. Agr. P. R. **25**(2) : 64–65, 94.

A brief account of a new method of transmitting artifically sugar cane mosaic and its practical application. This method is described in detail in Seín 1930 *a*, which see.

1930 *d*. Insectos que atacan la alfalfa en Puerto Rico. Rev. Agr. P. R. **25**(2) : 91.

A brief account of *Dichomeris piperata* Wlsm. as a new pest of alfalfa.

1930 *e*. *Dichomeris piperatus* Walsingham, a pest of alfalfa in Puerto Rico. Jour. Econ. Ent. **23**(5) : 885–886.

A brief note on this species as a new pest of a new crop.

1931 *a*. The pickle worm in chayote in Porto Rico. Jour. Econ. Ent. **24**(3) : 762.

1931 *b*. Informe sobre el brote del "Apate francisca" en Lares. El Agricultor Puertorriqueño **11**(7) : 24, San Juan.

Records a destructive outbreak of the coffee stem-borer in coffee and several other economic food-plants.

1931 *c*. El peligro de que pueda introducirse una nueva plaga del café. Bol. Agric. **1**(17) : 2, December 5, San Juan.

A short note on the danger of introducing the coffee weevil, *Stephanoderes coffea*, into Puerto Rico.

1932 *a*. Artificial transmission and other studies on sugar cane mosaic. Proc. Fourth Congress Int. Soc. Sugar Cane Techs., pp. (Preprint Bul. **84**) : 1–6, San Juan.

Includes notes on *Aphis maidis* and *Sipha flava*.

1932 *b*. Soil animals and root disease in Porto Rico. Proc. Fourth Congress Int. Soc. Sugar Cane Techs. pp. (Preprim Bul. **91**) : 1–2, San Juan.

Sepúlveda, A. E. 1931. La oruga roedora de la hoja del algodón. Campaña para combatirla. Rev. Agr. P. R. **26**(9) : 88, March.

Notes on a control campaign against a bad outbreak of the cotton leaf worm.

Sharp, David. 1890. Biologia Cent. Am. Coleoptera. Nitidulidae. **1**(2) : 304.

Coproporus (as *Erchomus*) *rutilus* as a new species from St. Thomas and Puerto Rico and *Colopterus* (as *Colastus*) *truncatus* Rand. listed from Puerto Rico.

Sicard, A. 1922. Descriptions de variétes, especes, et genres nouveaux appartenant a la famille de Coccinellides. Ann. and Mag. Nat. Hist., (Ser. 9) **9** : 349–360.

Scymnillus varipennis, *S. nunenmacheri*, *Scimnillodes cyanescens*, and *Psorolymna maxillosa*, all as new species from Puerto Rico.

Smyth, E. G. 1916. Report of the South Coast laboratory. Fourth Rept. Bd. Comm. Agr. P. R. from July 1st to June 30th 1915, pp. 44–50.

Note on fumigation with sulfur of boats with cane coming to Puerto Rico from Santo Domingo to prevent introduction of *Calisto pulchellus* (as *archebates*); white grub life-history studies.

1917 *a*. Report of the entomological department. Ann. Rept. Ins. Exp. Sta. P. R. from 1st July, 1916 to 30th June, 1917, pp. 96–106.

A summary of incoming plant inspection interceptions; reference is made to the fumigation of sugar cane entering from Santo Domingo to prevent introduction of the cane butterfly, *Calisto pulchellus* (*C. archebates* is used).

1917 *b*. The white grubs injuring sugar cane in Porto Rico. I. Life-cycles of the may beetles or melolonthids. Jour. Dept. Agr. P. R. **1**(2): 47–92, 8 pls. and **1**(3): 141–169.

P. portoricensis, vandinei, citri, guanicana, described as new species.

1918. Cómo combatir el gorgojo de la batata. Rev. Agr. P. R. **1**(3): 136–139.

Control of the sweet potato weevil.

1919 *a*. A résumé of plant quarantine work in Porto Rico from July 1916 to July 1919. Ins. Exp. Sta. P. R. Bul. **23**, 56 pp., 20 tables.

The title of the bulletin itself is "Plant inspection and quarantine report (1918–19)."

1919 *b*. Insects and mottling disease. Jour. Dept. Agr. P. R. **3**(4): 83–116.

Innoculation experiments with several species of insects

1919 *c*. An annotated bibliography of Porto Rican cane insects. Jour. Dept. Agr. P. R. **3**(4): 117–134.

1919 *d*. List of the insects and mite pests of sugar cane in Porto Rico. Jour. Dept. Agr. P. R. **3**(4): 135–150.

1919 *e*. Un insecto extraño que cubre su cría lo mismo que una gallina. Rev. Agr. P. R. **2**(4): 27–31, 2 figs.

Notes on the habits of *Pachycoris torridus* Scop.

1919 *f*. Dominio de insectos de los cítricos en Puerto Rico. Rev. Agr. P. R. **3**(1): 39–50 and **3**(3): 55–62.

Directions for the control of the more important citrus insects.

1919 *g*. Cómo se coleccionan y conservan los insectos. Rev. Agr. P. R. **3**(2): 17–33.

Directions for collecting and preserving insects.

1919 *h*. Dominio de la plaga de la mosca del ganado en Puerto Rico. Rev. Agr. P. R. **3**(5) : 10–**24**(6) : 17–28, 4 pls.

Suggestions on the control of the horn fly of cattle, ***Haematobia irritans*** L.

1919 *i*. Dominio de la plaga de la mosca cornúpeta del **ganado** en Puerto Rico. Rev. Agr. P. R. **3**(6) : 17–28.

Almost the same as above.

1919 *j*. Report of the Division of entomology. Ann. Rept. Ins. Exp. Sta. P. R. 1st July, 1917 to 30th June, 1918 pp. 109–129.

Notes on insect pest interceptions in connection with quarantine work; experiments in dissemination of sugar cane mosaic by insects; cane insects; rhinoceros beetle injury to coconuts; vegetable insects and on termites.

1919 *k*. Report of the division of entomology. Ann. Rept. Ins. Exp. Sta. P. R., 1918–1919, pp. 27–31.

Notes on further experiments in the transmission of sugar cane mosaic by insects and on experiments with paraffin oil emulsion for the control of scale insects; this latter was ineffective against *Pseudococcus nipae* on guava.

1920 *a*. The white grubs injuring sugar cane in Porto Rico. II. The rhinoceros beetles. Jour. Dept. Agr. **4**(2) : 3–29, 4 pls.

A detailed study of the economic importance, life history and control of *Strategus titanus* and *S. quadrifoveatus*.

1920 *b*. Nuestro amigo el Anolis. Rev. Agr. P. R. **4**(5) : 11–21.

Notes on the various insects eaten by the abundant and wide-spread lizards of the genus Anolis in Puerto Rico.

1920 *c*. Informe de la división de entomología. Mes de junio. II. La junta técnica de cuarentena. Rev. Agr. P. R. **5**(4) : 29–34.

Notes on cotton insects and the visit of U. C. Loftin to look for the cotton pink bollworm.

1920 *d*. Cotton insects in Porto Rico. Ent. News **31**(5) : 121–125.

A summary account of all the insects observed to date affecting cotton in the Island with notes on their distribution, injury and control.

1920 *e*. To keep out cane butterfly. Jour. Econ. Ent. **13**(1) : 149.

Note on successful efforts of the plant quarantine officials in Puerto Rico to keep cane from being shipped into the Island from Santo Domingo in order to prevent the introduction of the cane butterfly, *Calisto pulchellus* (given as *C. archebates*).

1920 *f*. Annual report, division of entomology. Ann. Rept. Ins. Exp. Sta. 1919–20, pp. 83–89.

Notes on continuation of work with insects as transmitters of cane mosaic, inauguration of a special plant quarantine service and recent regulations against cotton from Puerto Rico on account of *Eriophyes gossypii.*

1921. La mosca del ganado. Est. Exp. Ins. Circ. **39**: 1–17, 4 pls.

General account of the horn fly of cattle in Puerto Rico with remedies. A revision of Smyth 1919 *h*.

Snyder, P. G. 1920. Beekeeping in foreign lands. Gleanings in Beeculture **48**: 721–724, 3 figs.

Refers entirely to conditions in Puerto Rico.

Snyder, T. E. 1923. A new Glyptotermes from Porto Rico. Proc. Ent. Soc. Wash. **25**(4): 91–93, pl. 8.

Glyptotermes corniceps from Boquerón, P. R.

1924. Descriptions of new species and hitherto unknown casts of termites from America and Hawaii. Proc. U. S. Nat. Mus. Vol. **64**, (No. 2496, Art. 6): 10–12, pl. 2.

Glyptotermes pubescens as new from Puerto Rico.

Stahl, Agustín. 1882. Fauna de Puerto Rico. Clasificación sistemática de los animales que corresponden a esta fauna y catálogo del gabinete zoológico del Doctor A. Stahl en Bayamón, P. R. Imprenta del Boletín Mercantil, San Juan, P. R. Insects. Pt. 2, pp. 169–213.

A list of the species of insects in Dr. Stahl's collection in Bayamón, P. R., from Cuba, Trinidad and Puerto Rico.

* 1894. La enfermedad de la caña y el caculo. Imp. Sucesión J. J. Acosta, 18 pp., San Juan P. R. (Reference from Pedreira.)

Stevenson, J. A. 1918 *a*. Cuarentena de las plantas. Rev. Agr. P. R. **1**(4): 176–180.

A brief article on the reasons for and operations of plant quarantines.

1918 *b*. The green muscardine fungus in Porto Rico. (*Metarizhium anisopliae* (Metsch.) Sorokin.) Jour. Dept. Agr. P. R. **2**(1) : 19–32, 3 figs.

The species of insects attacked by the fungus in breeding cages in Puerto Rico is given and includes *Phyllophaga* and other common Scarabeids. Conclusion is reached that it will not serve as a practical means of controlling white grubs in the Island due to great dependance on humidity and other factors.

Stevenson, J. A. and **Cotton, R. T.** 1918. Preparation and use of lime-sulfur. Ins. Exp. Sta. Circ. **13**, 9 pp.

Strong, L. A. 1921 *a*. Quarantine Division. Reports for the months of July and August 1921. Mthly. Bul. Cal. Dept. Agr. **10**(9) : 381–385.

Records *Lepidosaphes beckii* intercepted on grapefruit from Puerto Rico.

1921 *b*. Quarantine division. Synopsis of work for the month of March, 1921. Mthly. Bul. Cal. Dept. Agr. **10**(5–6) : 212.

Lepidosaphes beckii listed as intercepted on grapefruit from Puerto Rico.

1922. Bureau of plant quarantine. Synopsis of work for the months of January and February 1922. Mthly. Bul. Cal. Dept. Agr. **9**(5–6) : 471–476.

Records *Lepidosaphes* beckii intercepted on oranges from Puerto Rico.

Suffrian, C. G. L. E. 1852. Zur Kentniss der Nordamerikanischen Cryptocephalen. Linnaea Entomologica **6** : 282–283 and **7** : 85 and 203.

Vol. **6** : 282–283, *Cryptocephalus nigrocinctus* as a new species and Vol. **7** : 85 and 203, *Cryptocephalus polygrammus* and *Pachybrachys praetextatus* as new species, all from Puerto Rico.

Tapia y Rivera, Alejandro. 1854. Biblioteca histórica de Puerto-Rico, que contiene varios documentos de los siglos XV, XVI, XVII y XVIII, coordinados y anotados, 6 + 587 pp. + 14, Puerto Rico.

On pp. 21–22 is a brief note that in 1510 Sotomayor founded the settlement of Guánica which he and his companions were obliged to vacate because of the great abundance of mosquitoes. (Oviedo, q. v.).

Teague, M. M. 1925. A review of the genus Aclerda (Hemipptera; Coccoidea). Ann. Ent. Soc. Am. **18**(4) : 439, 3 figs.

Aclerda sacchari described as a new species from Arecibo and Morovis, P. R., on stalks and roots of sugar cane (Geo. N. Wolcott, collector).

Thomas, W. A. 1928. The Porto Rican mole cricket. U. S. Farmers' Bul. 1561, pp. 1–9, 3 figs.

General account of economic importance, life-history, and control of *Scapteriscus vicinus* Latr. which was introduced into the Southern States supposedly from Puerto Rico, probably in the ballast of ships.

Torres, Ignacio L. 1927. El gorgojo del ñame del guineo (*Cosmopolites sordidus*). Rev. Agr. P. R. **19**(2): 56–58, 2 figs.

A general popular account of the insect and its control in Puerto Rico.

1928. Algo sobre algodón Sea Island. Rev. Agr. P. R. **22**(9): 91–92, 3 figs., March.

Brief account of the cotton industry in Puerto Rico and of the more important insect pests and their control.

1929. El cultivo de papas en Puerto Rico. Rev. Agr. P. R. **24**(6): 239–242.

It is stated on p. 241 that more or less damage was done to experimental plots of Irish potatoes at Cidra, Comerío, Barranquitas, Adjuntas, and Lares by mole crickets, flea-beetles, white grubs, the potato tuber moth, *Phthorimaea operculella*, and the cutworm, *Xylomiges sunia*; good control of leaf-feeders was obtained in an experimental plot at Lares with copper-lime-arsenate dust.

1931. Campaña contra el gusano rosado del algodón. Rev. Agr. P. R. **26**(11): 175–176, May.

A radio talk to explain to cotton growers the bad situation with regard to the pink boll worm and to outline measures for its relief.

Tower, W. V. 1907. Report of the entomologist and plant pathologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1906, pp. 25–28.

This is Mr. Tower's first report. Brief notes on the status and control of insects attacking citrus, coffee and cane.

1908 *a*. Report of the entomologist and plant pathologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1907, pp. 31–38.

Notes on insects affecting citrus, tobacco, vegetables, sugar cane and pineapples.

1908 *b*. Control of the brown ant (*Solenopsis geminata* Fab.)

and the mealy bug (*Pseudococcus citri* Risso) in pineapple plantations. P. R. (Mayagüez) Agr. Exp. Sta. Circ. **7**: 1–3.

The mealy bug is *Pseudococcus brevipes* Ckll. instead of *citri*.

1909. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1908, pp. 23–28.

Notes on insects affecting citrus, pineapples and coffee; Italian bees introduced.

1910. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1909, pp. 24–28.

Notes on insects affecting citrus, on white grub injury to cane, on cigarette beetle fumigation and on apiculture.

1911 *a*. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1910, pp. 31–34.

Notes on guava insects, citrus fumigation, the coffee shade-tree ant and on apiculture; brief report on a trip to Cuba to study cane insects.

1911 *b*. Insects injurious to citrus fruits and methods for combating them. P. R. (Mayagüez) Agr. Exp. Sta. Bul. 10, 35 pp., 5 pls. Also a Spanish edition of 36 pp. in 1912.

General account of the more important species present; the first comprehensive account for the Island.

1911 *c*. Beekeeping in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Circ. **13**: 1–31 pp., 1 pl. Also a Spanish edition.

1912 *a*. A study of the mosquitoes in San Juan, Porto Rico. P. R. (Mayagüez) Agr. Esp. Sta. Circ. **14**: 1–23. Also a Spanish edition in 1913.

1912 *b*. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1911, pp. 32–36.

Notes on apiculture and on citrus and mango insects.

1912 *c*. Beekeeping in Porto Rico. First Ann. Rept. P. R. Hort. Soc. for 1912, pp. 64–68.

Brief notes on the possibilities of developing a beekeeping industry in Puerto Rico and notes on the more important honey plants.

1920 *a*. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1918, pp. 15–17.

Mostly notes on apiculture.

1920 *b*. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1919, pp. 21–25.

Notes on mosaic transmission tests and on honey plants; a citrus thrips population survey noted is especially interesting altho the species involved were, apparently, not determined; injury to oranges was noted in several places.

1921 *a*. Report of the entomologist. P. R. (Mayagüez) Exp. Sta. Rept. for 1920, pp. 23–27.

Brief notes on apiculture, mosquitoes, cattle ticks and on scale insects of citrus.

1921 *b*. Mosquito survey of Mayagüez. P. R. (Mayagüez) Agr. Exp. Sta. Circ. **20**: 1–10 pp.

1922. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1921, pp. 23–26 (published as U. S. Dept. Agr., Office of Exp. Sta. Bul. 171).

Records trials of sugar cane mosaic transmission with *Sipha flava* and other insects; notes on cattle tick work and on apiculture.

1923. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1922, pp. 13–14.

A report on spraying experiments for the control of citrus scab.

1923. The cigar beetle. P. R. (Mayagüez) Agr. Exp. Sta. Agr. Ext. Notes No. 60, 1 p. (mimeographed).

Damage to cigars and to loose leaf tobacco in bales by *Lasioderma serricorne* F. in Puerto Rico is described and advantages of fumigation are pointed out.

1924. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1923, pp. 11–15.

Notes on fumigation for the cigarette beetle in tobacco factories, control of citrus insects, cotton insects and melon and cucumber insects.

Tracy, S. M. 1903. La cría del cerdo en el sur. Dept. Int. P. R., Neg. Agr. y Minas, Bol. Agr. 8. pp. 45–46.

A Spanish translation of U. S. Farmers' Bul. 100 "Hog raisng in the South," 1899, which includes a brief description of the hog louse and its control.

Tucker, C. M. 1924. The coconut bud-rot in Porto Rico. P R. (Mayagüez) Agr. Exp. Sta. Agr. Notes No. 2, 2 pp., 15th April.

Stated that insects are attracted to decaying buds and rotted

portions and are one of the means of disseminating the disease in Puerto Rico.

U. S. Dept. Agr., Fed. Hort. Bd. 1922. Service and Regulatory announcements, July–December 1921, No. 71, pp. 95–178. (Abs. in Rev. Appl. Ent. **10**: 595.)

Note on the extended infestation in Puerto Rico of *Pectinophora gossypiella* from which the U. S. is protected from introduction by the quarantine recently having been extended to Puerto Rico.

1925. Fruit and vegetable quarantine of Porto Rico. Notice of quarantine 58, 5 pp., May 27.

Anastrepha fraterculus, the West Indian fruit fly, and *Maruca testulalis*, the bean pod-borer, are specifically mentioned.

1926. Hawaiian and Porto Rican quarantine covering sand, soil or earth, with plants. Notice of quarantine No. 60, 1 p., February 19.

To prevent the spread of Lachnosterna and several species of Termites no sand, soil or earth around the roots of plants may be moved from these countries into the U. S. except for experimental or scientific purposes, effective March 1, 1926.

U. S. Dep. Agr.. P. Q. C. A. 1929. [Administrative instructions concerning Mediterranean fruit fly quarantine.] Circ. Nos. **229** & **234**, 2 pp., multigraph, Washington, D. C.

No host fruit or host vegetable from Florida may be moved or reshipped to any of 18 southern or western states or to Puerto Rico.

Van Deusen, Elizabeth Kneipple. 1930. Famous Porto Ricans of the past. Augustín Stahl. P. R. School Rev. **14**(5): **26–27**.

A biographical sketch of the foremost pioneer student of the natural history of Puerto Rico.

Van Deusen, R. J. and **E. K.** 1931. Porto Rico—A Caribbean Isle, 342 pp., many illustrations, New York.

A general history of Puerto Rico from prehistoric times to the present day. On p. 54 is a reference to the mosquito plague at Guánica in the year 1510.

Van Dine, D. L. 1911. (Cane insects). First report of the entomologist of the experiment station. Sugar Growers' Ass. P. R. Exp. Sta. Bul. 1, pp. 17–31. Also in Yearbook of Assn. Sugar Prod. P. R. for 1910–1911, pp. 43–57.

A general discussion of the more important sugar cane insects and their status in Puerto Rico.

1912 *a*. Report of the entomologist. Second annual report Sugar Prod. Assn. P. R. Exp. Sta. for the year 1911–1912, pp. 15–22.

Notes on the progress of investigations on various sugar cane insects.

1912 *b*. Daño ocasionado al jugo de la caña por el barreño del tallo o "borer". (*Diatraea saccharalis* Fab.) Est. Exp. Asoc. Prod. Azúcar P. R. Circ. 1: 1–11. Also an English edition, same date and number of pages entitled "Damage to sugar-cane juice by the moth stalk-borer".

1912 *c*. Progress report on introductions of beneficial parasites into Porto Rico. First Rept. Bd. Comm. Agr. P. R. for July 1, 1911–Jan., 1912, pp. 31–47.

Report on the preliminary studies in the U. S. and introduction from Illinois thru C. E. Hood of *Tiphia* parasites of white grubs; copy of Hood's report is included; also a record of the introduction of the lady beetle, *Cryptolaemus montrouzieri* from Calif. for *Pseudococcus* spp.

1912 *d*. The mango insect pests of Hawaii. First Ann. Rept. P. R. Hort. Soc. for 1912, pp. 15–19. La Bandera Press, Mayagüez.

Notes on the principal mango insects of Hawaii presented for the information of growers in Puerto Rico.

1912 *e*. Mango insects in Porto Rico. First Ann. Rept. P. R. Hort. Soc. for 1912, pp. 20–22.

Notes on the mango fruit fly (Anastrepha sp.), a scale insect and a thrips.

1913 *a*. The introduction of parasites of may-beetles into Porto Rico. Second Rept. Bd. Comm. Agr. P. R. for 1912–1913, pp. 36–48.

The work referred to in the previous report is reviewed and that done since, including Wolcott's activities in Illinois and his West Indian trip to study sugar cane insects and their parasites; breeding notes on the introduced *Tiphia*.

1913 *b*. Report of the entomologist. Third Ann. Rept. (Bul. 5) Sugar Prod. Assn. P. R. Exp. Sta., pp. 23–46.

1914. Informe del entomólogo. Bol. 5, Est. Exp. Asoc. Prod.

Azúcar de Puerto Rico. (Tercer inf. anual), pp. 27–48. (The Spanish edition of the preceding.)

Includes a list of 30 sugar cane insects in Puerto Rico and a bibliography of 41 titles.

* 1913 *c*. Insects injurious to sugar cane in Porto Rico and their natural enemies. Jour. Bd. Agr. British Guiana **4**(4): 199–203, April.

According to Wolcott (see his "List" p. 14) this contains the same information as in Van Dine 1913 b and d. The volume may be No. 6. I have not seen this personally.

1913 *d*. The insects affecting sugar cane in Porto Rico. Jour. Econ. Ent. **6**: 251–257.

A brief summary of all the insects found affecting sugar cane during the two years entomological investigations have been in progress at the P. R Sugar Producers' Exp. Station; brief previous history.

van Leenhoff, J. W. 1906. Report of the coffee specialist. Diseases and insect pests. P. R. (Mayagüez) Exp. Sta. Rept. for 1905, pp. 46–47.

Brief notes on *Leucoptera coffeella, Saissetia hemisphaerica* and leaf weevils (*Lachnopus*).

1907. Report of the coffee expert. Diseases and insect pests. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1906, pp., 31–32.

Mostly a brief note on a fertilizer experiment for the control of the coffee leaf-miner with results apparently negative to date.

1908. Report of the coffee expert. Diseases and insect pests. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1907, p. 40.

Note on a borer; the leaf-miner fertilizer experiment referred to previously is reported successful.

van Volkenberg, H. L. 1929 *a*. Report of the parasitologist. P. R. (Mayagüez) Agr. Expt. Sta. Rept. for 1927, pp. 28–31.

Several external parasites of domestic animals and poultry are recorded.

1929 *b*. Report of the parasitologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1928. p. 36.

Screw-worm flies are reported as common and open wounds in animals are always liable to infestation by the maggots.

1930. Report of the parasitologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1929, pp. 26–29.

Notes on cattle tick eradication.

1931. Report of the parasitologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1930, pp. 38–40.

Notes on the occurrence of a tapeworm cysticercoid in the dung beetle, *Ataenius stercorator* Fab. and in the water beetle, *Tropisternus collaris* Fab.

1932. Report of the parasitologist. P. R. (Mayagüez) Agr. Expt. Sta. Rept. for 1931, pp. 24–27, 1 fig.

Notes on various external parasites of livestock, including ticks, flies of various kinds, fleas and lice; an interesting observation is that the water-beetle, *Tropisternus collaris* Fab. is an intermediate, and apparently important, host of the thorny-headed worm, *Macracanthorynchus hirundinaceus*, of swine.

van Zwaluwenburg, R. H. 1915. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. for 1914, pp. 31–25.

Notes on mole crickets, coffee leaf-miner, coffee shade-tree insects and on other miscellaneous insects and on honeybees.

1916 *a*. Report of the entomologist. P. R. (Mayagüez) Agr. Expt. Sta. Rept. for 1915, pp. 42–45.

Notes on insects attacking coffee and coffee shade-trees, vegetables and on white ants, the coconut rhinoceros beetle and several miscellaneous pests.

1916 *b*. Notes on the life-history of *Ecpantheria eridanus* Cramer. Insec. Ins. Men. **4**: 12–17.

The studies were made in Puerto Rico.

1917. Insects affecting coffee in Porto Rico. Jour. Econ. Ent. **10**(6): 513–517.

A summary of the knowledge of this subject up to that time.

1918 *a*. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1916, pp. 25–28, 1 pl.

Notes on the cattle tick, mole cricket, may beetles, apiculture and miscellaneous insects.

1918 *b*. Report of the entomologist. P. R. (Mayagüez) Agr. Exp. Sta. Rept. for 1917, pp. 31–34.

Life-history data on the cattle tick, notes on a Phorid fly destructive to corn kernels and miscellaneous notes.

1918 c. The changa or West Indian mole cricket. P. R. (Mayagüez) Agr. Exp. Sta. Bul. **23**: 1–27 pp., 3 pls.

An excellent general account with extensive bibliography.

Van Zwaluwenburg R. H. and **Thomas, H. E.** 1918. Some means of controlling insects, fungi and other pests in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Circ. **17**: 1–30.

General account with control measures.

Van Zwaluwenburg, R. H. and **Vidal, Raphael.** 1918. Rearing queen bees in Porto Rico. P. R. (Mayagüez) Agr. Exp. Sta. Circ. **16**: 1–12, 5 figs. Also a Spanish edition.

Varas Catalá, Juan. 1922. Tabla por la que deberán regirse los ganaderos al preparar la solución arsenical con el concentrado Atlas cattle dip. Rev. Agr. P. R. **8**(3): 65–66.

Vickery, R. A. 1926. Observations on *Cirphis latiuscula* H. Sch. in the Gulf region of Texas. Jour. Agr. Res. **32**(12): 1099–1119, 3 figs., 14 refs.

Stated that this species is known in Tropical America, especially in Cuba and Puerto Rico as a pest of sugar cane and other large grasses.

Vidal, Rafael. 1916. Some of the needs of the Porto Rican Beekeeper. Gleanings in Beeculture **44**: 409–410, 1 fig.

Viereck, H. L. 1913. Descriptions of ten new genera and twenty-five new species of ichneumon-flies. Proc. U. S. Nat. Mus. **44**: (No. 1968): 555–568.

The following are described as new species from Puerto Rico: *Crassimicrodus fenestratus, Apanteles (Protapanteles) mayaguensis, Opius (Utetes) anastrephae, Eiphosoma (Brachixiphosoma) insularis* and *Cristolimorpha plesius.*

Voorhees, E. B. 1903. Cultivo del tomate en los Estados Unidos. Dept. Int. P. R.. Neg. Agr. y Minas Bol. Agr. 15, pp. 44–45.

Brief general account of tomato insects in this Spanish translation of U. S. Farmers' Bul. 76 on "Tomato Growing," 1898.

Walsingham, Lord. 1892. On the Microlepidoptera of the West Indies. Proc. Zool. Soc. London for 1891, pp. 492–549, 1 pl. (41).

Includes a number of species specifically stated to occur in Puerto Rico; apparently none described as new.

1897. Revision of the West Indian Microlepidoptera, with descriptions of new species. Proc. Zool. Soc. London for 1897, pp. 54–182.

This brings the previous paper up to date.

Walton, W. R. 1912. A new species of Tachinidae from Porto Rico. Proc. Ent. Soc. Wash. **14**(4): 198–200, 1 pl.

Cryptomeigenia aurifacies, a parasite of May-beetles.

1913. New North American Tachinidae (Dipt.). Ent. News **24**(2): 49–51, pl. 3, figs. a-f.

Eutrixoides jonesi as a new genus and species from Puerto Rico. another parasite of May-beetles.

1914. Four new species of Tachinidae from North America. Proc. Ent. Soc. Wash. **16**(2): 93–95.

Linnaemyia fulvicauda and *Compsilura oppugnator* as new species parasitic on *Cirphis latiuscula* H. S. from Puerto Rico.

Watts, R. L. 1903. Cultivo de la cebolla. Dept. Int. P. R., Neg. Agr. y Minas, Bol. Agr. 9, p. 27.

A Spanish translation of U. S. Farmers' Bul. 39 "Onion Culture," 1896, which includes a brief account of the onion maggot and its control.

Weise, J. 1885. Beitrag zur Chrysomeliden—und Coccinelliden-Fauna Portorico's. Archiv für Naturgeschichte 51(1): 144–168, pl. 8.

The following species are described as new: *Lema nigripes* and *Cryptocephalus tristiculus,* p. 147, *krugi,* p. 148, *stolidus,* p. 149, *perspicax,* p. 151 and *nothus,* p. 152; *Pachybrachys mendicus,* p. 153; *Metachroma antennalis,* p. 155; *Leucocera laevicollis,* p. 156; *Galerucella varicornis,* p. 157; *Disonycha pallipes,* p. 159; *Hermoeophaga cylindrica,* p. 160; *Megistops fictor,* p. 162; *Homophyla krugi,* p. 163; *Systena varia,* p. 164; *Octhispa loricata,* p. 166.

Wetmore, Alex. 1916. Birds of Porto Rico. U. S. Dept. Agr. Bul. 326: 1–140 pp., 10 pls. Also published as Bul. **15** Ins. Exp. Sta. P. R., same date.

Contains a great deal of data on insects as the food of Puerto Rican birds.

Wheeler, Wm. M. 1908. The ants of Porto Rico and the Virgin Islands. Bul. Am. Mus. Nat. Hist. 24 (Art. 6): 117–158, pls. 11 & 12.

Describes 8 new species and varieties.

White, W. H. 1916. The sugar-beet thrips. U. S. Dept. Agr. Bul. **421**, p. 2, 8 figs., 2 pls.

Records *Heliothrips femoralis* Reut. as occurring on sugar cane in Puerto Rico.

Wiedemann, C. R. W. 1830. Aussereuropaische zweiflügelige Insekten 2, pp. 41–42.

Sargus bicolor as a new species from Puerto Rico.

Wolcott, A. B. 1923. Two new speciesof West Indian Cleridae (Coleoptera). Am. Mus. Novitates No. 59, 3 pp., 2 figs., February 14.

Callotillus crusoe as a new species from Puerto Rico.

Wolcott, Geo. N. 1913. Report on a trip to Demerara, Trinidad and Barbados during the winter of 1913. Jour. Econ. Ent. **6**(2): 443–457. Reprinted in Third Ann. Rept. (Bul. **5**) Sugar Prod. Assn. P. R. Exp. Sta. pp. 47–68. Also see "Informe sobre un viaje a Demerara, Trinidad y Barbados durante el invierno de 1913" in Bol. 5, Est. Exp. Asoc. Prod. Azúcar de Puerto Rico (Ser. Inf. Anual), p. 49–71, 1914.

A detailed report on observations on the insects affecting sugar cane and their parasites in the places visited.

1915. Influencia de la lluvia y quemazón de la paja sobre la abundancia de *Diatraea saccharalis*. Est. Exp. Asoc. Prod. P. R. Circ. **7**: 1–6, map. (Also in English "The Influence of Rainfall and the Non-Burning of Trash on the Abundance of *Diatraea saccharalis*".)

1917. Report of the entomologist. Fifth Rept. Bd. Comm. Agr. P. R. for the period from 1st July, 1915 to 30th June, 1916.

Notes on quarantine enforcement and inspection, control of scales on citrus, tobacco flea-beetles and their control, and a number of vegetable insects.

1921 *a*. Los comejenes de Puerto Rico. Est. Exp. Ins. Circ. **44**: 1–14, fig. 12.

General account of the more injurious termites of Puerto Rico and suggestions for their control.

1921 *b*. El caculo taladrador del tallo del cafeto (*Apate francisca* Fabr.). Est. Exp. Ins. Circ. **48**: 1–7, fig. 2.

General account of the coffee stem-borer and its control.

1921 *c*. El minador de las hojas del café, *Leucoptera coffella* Stain. Est. Exp. Ins. Circ. **52**: 1–12, fig. 6.

General account of the coffee leaf-miner and suggestions for its control.

1921 *d*. The minor sugar-cane insects of Porto Rico. Jour. Dept. Agr. P. R. **5**(2)5–46, fig. 19.

1921 *e*. Las plagas del cacao en Santo Domingo y algunas indicaciones para combatirlas. Rev. Agr. P. R. 6(6) : 11–12.

Mention that aphids and mealybugs are common in Puerto Rico as in Santo Domingo as well as in other Tropical countries.

1821 *f*. Annual report of the division of entomology. Ann. Rept. Ins. Exp. Sta. P. R., 1920–21, pp. 47–49.

Experiments in insect transmission of sugar cane mosaic by insects; notes on banana and coffee insects and on *Phthorimaea operculella* Zell., stated to be the most important insect of the year, injuring tobacco, potato tubers and egg plants.

1922 *a*. Los gusanos de la hoja del tabaco. Est. Exp. Ins. Circ. **53**: 1–15, fig. 8, pl. 1.

Brief general account of the horn worm, leaf-miner and cutworms of tobacco.

1922 *b*. Afidos de importancia económica en Puerto Rico. Est. Exp. Ins. Circ. **59**: 1–11, fig. 9.

Brief account of the more important injurious aphids in Puerto Rico.

1922 *c*. Vaquitas de importancia económica en Puerto Rico. Est. Exp. Ins. Circ. **60**:1–20, fig. 20.

Brief account of the more important injurious weevils in Puerto Rico.

1922 *d*. Insectos que atacan los productores almacenados. Est. Exp. Ins. Circ. **65**: 1–8.

Brief account of the principal insects attacking foods and stored products in Puerto Rico.

1922 *e*. Insect parasite introduction into Porto Rico. Jour. Dept. Agr. P. R. **6**(1) : 5–20, fig. 7.

An excellent summary of the history and present status of parasite introduction.

1922 *f*. The influence of the variety of sugar-cane on its infestation by *Diatraea saccharalis* and other factors affecting

the abundance of the moth borer. Jour. Dept. Agr. P. R. **6**(1) : 21–31, fig. 2.

An analysis of the various factors involved: rainfall, varieties and parasites.

1922 *g*. The insects of sugar cane in Santo Domingo. Jour. Dept. Agr. P. R. **6**(1) : 32–37, pl. 1.

An annotated list of 32 species compiled from 5 months' observations by the author, notes made by Tower of Puerto Rico during a trip to the country and from determinations of collections from the Romana Central and from notes by E. G. Smyth of Puerto Rico. Some occur in Puerto Rico.

1922 *i*. The status of entomology in Porto Rico. Jour. Dept. Agr. P. R. **6**(2) : 3–11. (Also either reprinted or abstracted in Sugar (Review) 26: 93, Feb., 1924, New York.)

A valuable summary of the history of entomological work in the Island and of the activities of the principal workers and agencies by which it has been accomplished.

1922 *j*. Informe de la estación experimental insular. Informe del departamento de entomología. Rev. Agr. P. R. **8**(2) : 65–68.

Notes on several insects injurious during the year.

1922 *k*. Curso de instrucción a los maestros y agentes agrícolas (Entomología). Rev. Agr. P. R. **8**(3) : 21–30.

1922 *l*. Informe sobre un viaje hecho a la región algodonera para observar las plagas de insectos que atacan al algodón. Rev. Agr. P. R. **9**(3) : 15.

1922 *m*. A reaction to a variation in light intensity by the coffee leaf miner. Ecology **3**(1) : 86.

An observation indicating that both the moths and caterpillars of *Leucoptera coffella* are remarkably sensitive to variations in subdued light intensities.

1922 *n*. The distribution of the pink bollworm of cotton, *Pectinophora gossypiella* Saunders, in Porto Rico. Jour. Econ. Ent. **15**(4) : 313–314, map.

Presents a summary of the results of a survey made during the winter and spring of 1922.

1922 *o*. Informe anual de la división de entomología para el

año fiscal de 1921 a 1922. Inf. An. Est. Exp. Ins. P. R., 1921–1922, pp. 55–60.

Notes on experiments in the control of white grubs and in insect transmission of cane mosaic and on coffee insects; several other injurious insects noted and reference is made to the discovery of the pink bollworm and the banana root-weevil during 1921.

1922 *p*. Tres cartas. Rev. Agr. P. R. **9**(5) : 39–40.

Letters concerning beetles which injure the sweet potato, and the cotton leaf worm.

1923 *a*. El cucubano, *Pyrophorus luminosus* Illiger. Est. Exp. Ins. Circ. **50** : 1–8, 3 figs.

Life-history, distribution and economic importance; beneficial habits of larva, which devours large numbers of white grubs (*Phyllophaga* spp.).

1923 *b*. The distribution of the pink bollworm in Porto Rico. Ins. Exp. Sta. Circ. **85** : 1–7, 1 map.

Brief account of spread from time of discovery and results of a survey made during the winter and spring of 1922–1923.

1923 *c*. "Insectae Portoricensis," a preliminary annotated check-list of the insects of Porto Rico, with descriptions of some new species. Jour. Dept. Agr. P. R. **7**(1) : 1–313, 2 pls. (Actual date of publication, March 5, 1924.)

About 2,300 species listed, with localities, food-plants, dates and much bibliographical data; 32 species are described as new.

1923 *d*. Entomological papers. The food of Porto Rican lizards. Jour. Dept. Agr. P. R. **7**(4) : 5–37. (issued August, 1924.)

1923 *e*. Entomological papers. First supplement to Insectae Portoricensis. Jour. Dept. Agr. P. R. **7**(4) : 38–43. (Issued August, 1924.)

Corrections and additions.

1923 *f*. An important new pest of beets in Porto Rico. Jour. Econ. Ent. **16**(6) : 459–460.

Notes on the injury, abundance, food-plant and natural enemies of *Disonycha laevigata* Jacoby.

1924 *a*. Entomología Económica Puertorriqueña. Est. Exp. Ins. P. R. Bol. **32** : 1–176, 12 pls. 97 figs.

General account of the more important economic insects in Puerto Rico with control measures. A very useful paper.

1924 *b*. Hormigas. Est. Exp. Ins. P. R. Circ. **75**: 1–11.

General account of the more important injurious ants in Puerto Rico and their control; 45 species of ants known to occur in the Island.

1924 *c*. Annual report of the division of entomology for the fiscal year 1922–23. Ins. Exp. Sta. P. R. Rept. for 1922–1923, pp. 51–57.

Notes on white grub and sugar cane mosaic transmission experiments; coffee shade tree insects and bees in coffee groves, banana root borer, tobacco leaf-miner, pink bollworm, cotton leaf-worm and on other cotton insects.

1924 *d*. Annual report of the division of entomology, fiscal year 1923–24. Ins. Exp. Sta. Rept. for 1923–24, pp. 88–103.

Notes on white grub control, on the coffee shade-tree ant and its control, on pink bollworm, banana root borer, termites and several other injurious insects.

1925 *a*. The comparative resistance of woods to the attack of the termite, *Cryptotermes brevis* Walker. Ins. Exp. Sta. P. R. Bul. **33**: 1–15.

A list of the different kinds of woods arranged in order of their comparative resistance to attack shows that cypress is absolutely resistant and mahogany somewhat less so.

1925 *b*. On the amount of food eaten by insects. Jour. Dept. Agr. P. R. **9**(1) : 47–58.

Feeding experiments with several species of insects carried on in Puerto Rico.

1926. Notes on the insects of the sea-grape, *Coccoloba uvifera* (L.) Jacq. in Porto Rico and adjacent countries. Bul. Ent. Res. **17**(1) : 49–52.

1927. Common insect pests prefer other host plants in Haiti. Jour. Econ. Ent. **20**(2) : 429–430.

Systena basalis Duv. stated to be usually on tobacco in Puerto Rico but on cotton in Haiti and *Nezara viridula L.* but once recorded as damaging tobacco in Puerto Rico and observed also commonly in a field in Haiti altho it occurs mainly on cotton in the Lesser and on tomatoes and peppers in the Greater Antilles.

1928. The maybeetles of Haiti (Scarabeidae: Coleoptera). Proc. Ent. Soc. Wash. **30**(2) : 21–29.

The abundance of *Phyllophaga* in Puerto Rico is referred to on page 21.

1929 *a*. The mystery of *Alabama argillacea*. Am. Nat. **63**, (684): 82–87.

"In the scattered cotton fields of Puerto Rico, *Alabama* sometimes appears in destructive numbers but in other years is not to be seen."

1929 *b*. Notes on the life history of *Exophthalmus quadrivittatus* Oliv. (Coleoptera). Proc. Ent. Soc. Wash. **31**(2): 21–26.

Mention of injuries by *Diaprepes* in Puerto Rico is made on page 21.

1929 *c*. Weather and the non-burning of trash in borer control in Porto Rico. Trans. 4th Int. Congress Ent. **2**: 62–64.

Extensive observations show that infestation by the sugar cane borer, *Diatraea saccharalis* Fab. is inversely proportional to the amount of rainfall and worse where the trash is burned due to destruction of parasites.

1931. The infestation of young okra pods by the pink bollworm in Porto Rico. Jour. Dept. Agr. P. R. **15**(4): 395–398.

1932 *a*. Insect conditions in Porto Rico during February, 1932. Ins. Pest Surv. Bul. **12**(2): 76, April 1.

1932 *b*. On methods of determining borer abundance in cane fields. Proc. Fourth Congress Int. Soc. Sugar Cane Techs. (Preprint Bul. **88**: 1–2), San Juan, P. R.

Experiments carried on in Puerto Rico are referred to.

1932 *c*. Insect conditions in Puerto Rico during July, 1932. Ins. Pest Surv. Bul. **12**(6): 293.

Notes on the cottony cushion scale and lima bean pod-borers.

1932 *d*. Insect conditions in Puerto Rico during August, 1932. Insect Pest Surv. Bul. **12**(7): 338, September 1.

A note is included on the status of the cottony cushion scale, *Icerya purchasi* Mask., as of the middle of August.

1932 *e*. The effect of the hurricane of San Cyprian on insects in Puerto Rico. Ins. Pest Surv. Bul. **12**(9): 409–410.

Some insects present in normal numbers and others reduced; notably among the latter is the cottony cushion scale, which however was undoubtedly considerably extended in its distribution.

Wolcott, G. N., More, J. D. and Seín Jr., F. 1921. La oruga rosada de la cápsula del algodón en Puerto Rico. Est. Exp.

Ins. P. R. Circ. 63, 12 pp., 3 figs. Reprinted under the same title in the Agricultor Puertorriqueño **11**(7): 7–8, 28, 3 figs., 1921.

General account of the discovery, distribution life-history, and control of the pink bollworm of cotton in Puerto Rico.

Wolcott. G. N. and **Seín Jr., F.** 1921. La lapa del tabaco y otras siembras. Est. Exp. Ins. P. R. Circ. **51**.

General account of the damage and control of the slug, *Veronicella occidentalis* Guild. on tobacco and other crops in Puerto Rico.

Wolcott, G. N. and **Seín Jr., F.** 1922. Los caculos cornudos o los escarabajos rinocerontes de Puerto Rico. Est. Exp. Ins. P. R. Circ. **53**: 1–13, 4 pls.

Brief general account of *Strataegus quadrifoveatus* Beauv. and *S. titanus* Fab.

1931. La oruga rosada de la cápsula del algodón en Puerto Rico. Est. Exp. Ins. P. R. Circ. **95**: 1–13, 4 figs.

General account of the pink bollworm in Puerto Rico and suggested control measures.

APPENDIX

As a partial guide or index to this bibliography the following list of authors is given. The names are grouped largely under the orders of insects, altho several general subjects such as malaria, apiculture, and plant quarantine are included. Altho it will be found by turning to the references cited under these authors that the papers are mostly of a systematic nature, the names of authors of some of the more important economic papers have also been included, especially where a paper deals with a single species. Where no date follows an author's name it means that there is either only a single reference listed for that author or that all the references by that author deal with the group of insects or subject designated.

APICULTURE

Anonymous, 1928 *a*, 1928 *b*; Abad, J.R.; Baldorioty de Castro; Brenner; Colón, E. D., 1930; Cuevas Zequeira; Holmer & Little; Iches; Ledru; Phillips; Sein, 1923 *b*; Snyder, T. G.; Tower, 1911 *c*, 1912 *c*, 1920 *a*, 1921 *a*; Van Zwaluwenburg & Vidal; Vidal.

ARACHNIDA

Banks, 1901, 1917; Chamberlin, 1917, 1922 (millipedes), Cotton, 1917 *c*; Koch; Lutz; Petrunkevitch; Seely.

COLEOPTERA

Anonymous, 1932; Aube; Ballou, 1913, 1916; Baly; Barrow; Blake; Boheman; Bovel; Bryant; Catoni, 1932 *e*; Champion; Chapin; Chapuis; Chevrolat, L. A. A.; Chevrolat, M. A.; Clark, Hamlet; Cotton, 1917 *b*, 1918 *b*, 1918 *d*; Crespo, 1920; Danforth, R. E.; Erichson; Erichson in Germar; Fauvel; Fischer; Fisher; Fletiaux; Gahan, C. J.; Gerstaecher; Gómez; González Ríos, 1922; Hutson; Illiger; Jacoby; Jones, 1915 *c*; Kolbe, 1907, 1910; Lacordaire; Leng & Mutchler; Leonard, 1930 *b*, 1931 *c*; Leveille; Lewis; López Tuero; Mäklin; Marshall; Montgomery & Bragdon; More, 1921 *a*, *b*, *c*; Moser; Mutchler; Notman; Ochs; Pierce, 1915, 1918; Quedenfeldt; Quintanilla; Reitter; Ritchie; Rivera; Sasscer, 1921, Sein, 1923 *c*, 1929, 1931 *b*, *c*; Sharp; Sicard; Smyth,

1917 *b*, 1918, 1920 *a*; Suffrian; Torres, 1927; Tower, 1923, 1924; Weise; Wolcott, A. B.; Wolcott, G. N., 1921 *b*, 1922 *c*, 1923 *a*, *b*, 1928, 1929 *b*; Wolcott & Seín, 1922.

DIPTERA

Aldrich; Alexander; Bigot; Bradt; Coquillett; Cresson Jr.; Curran; Dickmans, 1927 *a;* Dyar, 1907, 1924, 1928; Felt; Frost; González Ríos, 1923; Gundlach; Hoffman, 1925, 1927; Knab; Leonard & Sein, 1931; Loew; Macquart; Malloch; M. A. M.; Melander; Osten Sacken; Parker; von Roeder; Smyth, 1919 *h*, *i*.
lander; Osten Sacken; Parker; von Roeder; Smyth, 1919 *h*, *i;* Wiedemann; Walton.

HEMIPTERA

Barber; Barber & Bruner; Cotton, 1917 *a;* Drake; Gundlach; Harris; Leonard, 1931 *b*, 1932 *c;* Leonard & Mills, 1931 *b*.

HOMOPTERA

Catoni, 1923 *d;* Cockerell, 1895; Cotton, 1917 *d;* Davis; Dozier, 1925, 1926 *b*, 1927 *a*, *b*, 1931; Fernald; Ferris; Funkhouser; Gibson; Gundlach; Hernández; Hottes & Frison; Jones, 1915 *a*, 1917 *a;* Leonard, 1930 *a*, 1932 *l;* Mari; Marlatt, 1908; McAtee; McClelland & Tucker; Menéndez Ramos; Morrison; Muir, 1918, 1924; Muir & Giffard; Osborn; Pergande & Cockerell; Quaintance; Quaintance & Baker; Sasscer, 1920; Teague; Wolcott 1922 *b*, 1932 *d*.

HYMENOPTERA

Ashmead; Barret, 1904; Berger, 1921; Bishoff; Cockerell, 1910, 1919; Crawford; Cresson; Dewitz, 1881; Díaz; Dodd; Dozier, 1926 *a*, *c*, 1932 *a*, *b;* Gahan, A. B.; Girault; Gundlach; Herrera; Hooker, 1912; Leonard, 1933 *b*; Mann; Muesebeck; Rohwer; Myers, 1931 *b;* Rohwer; Tower, 1908 *b;* Van Dine, 1913 *a;* Viereck; Wheeler; Wolcott, 1925 *a*.

ISOPTERA

Banks, 1919; Banks & Snyder; Crespo, 1919; Snyder, 1923, 1924; Wolcott, 1921 *a*, 1925 *a*.

LEPIDOPTERA

Aurivillius etc.; Box, 1931; Brown; Chittenden; Clark, B. Preston; Dewitz, 1877 *a*, *b;* Dyar 1922; Forbes; Forbes & Leonard; Gundlach; Hampson; Holloway; Holloway, Haley & Loftin; Hol-

loway & Loftin; Jones, 1913, 1915 *b*, 1917 *b;* Jones & Wolcott; **Klotz,** A. B.; Langston; Lathy; Leonard & Mills, 1931 *a;* Leonard **&** **Sein**, 1932; Linnaeus; Medina; Mills & Leonard; Molinary **Sales**; More, 1931 *d;* Möschler; Pagenstecher; Pastor **Rodríguez**, **1931** ***a***, ***b;*** Rothschild; Rothschild & Jordan; Saavedra; Schaufuss; **Sein**, 1926, 1929 *c*, *d*, 1930 *b*, *d*, *e*, 1931 *a*, 1932 *b;* Sepúlveda; Smyth, **1916**, 1917 *a*, 1920 *e;* Torres, 1931; U.S.D.A., Fed. Hort. Bd. 1922; **Van** Zwaluwenburg, 1916 *b;* Vickery; Walsingham; Wolcott, 1915, **1921** *c*, 1922 *a*, *f*, *m*, *n*, 1923 *b*, 1929 *a*, *c*, 1931, 1932 *b;* Wolcott, More & **Seín**; Wolcott & Seín, 1931.

MALARIA (Including Mosquitoes)

Anonymous, 1925, 1926, 1927 *c*, *d*, 1928 *c*, 1929; Bastón; **Earle**; **Earle** & Arbona; Hoffman, Marin & Burke; Howard, Dyar & Knab; **Dyar**, 1907, 1924; Johnson; King; Kudo; Ludlow; McKinley; **bard**; Saussure; Sein, 1923; Thomas; Van Zwaluwenburg, 1918 *c*.

NEUROPTERA

Gundlach; Kolbe, 1888.

ODONATA

Gundlach; Klotz, Elsie B.

ORTHOPTERA

Barrett, 1902; Brunner von Wattenwyl; Brunner von Wattenwyl & Redtenbacher; Burmeister; Caudell; Crossman & Wolcott; Dohrn; Gundlach; deHaan; Hebard; Moore; Rehn & Hebard; Saussure; Sein, 1923; Thomas; Van Zwaluwenburg, 1918 *c*.

PLANT QUARANTINE

Anonymous, 1911, 1913, 1915, 1920, 1921, 1923, 1924; Catoni, **1921** *i*, 1922 *d*, 1924; Crespo & Catoni; Faxon & Trotter; Smyth, **1919** ***a;*** Stevenson, 1918 *a;* U.S.D.A., Fed. Hort. Bd.; U.S.D.A., **P.Q.** & C.A.

SERICULTURE

del Campo; Sein, 1928; Colón, 1930.

SIPHONAPTERA

Carrión; Cox, Carrión & Fox; Dickmans, 1927 *b*.

STREPSIPTERA

Pierce, 1914.

THYSANOPTERA

Dozier, 1926 *d*; Hood; Leonard, 1932 *e*; Morgan; Russell; **White.**

THYSANURA AND COLLEMBOLA

Folsom; Sein, 1930, *b*.

VERTEBRATES (Birds, Toads & Lizzards)

Dexter; Anonymous, 1913 *a*; Danforth, S.T., 1926 Leonard, **1933 *a*;** Rosenfeld, 1925 *a*; Sein 1927; Smyth, 1920 *b*; Wetmore; **Wolcott,** 1923 *d*.

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NOTES ON INSECT CONDITIONS IN PUERTO RICO FOR THE FISCAL YEAR, JULY 1931 THRU JUNE 1932

By MORTIMER B. LEONARD
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This constitutes the third annual report by the writer on insect conditions in Puerto Rico. The first, for the fiscal year of 1929–1930, was published as part of the Report of the Division of Entomology in the Rept. Ins. Exp. Sta. P. R. for 1929–30, pp. 110–123, 1931. The second appeared in the Jour. Dept. Agr. P. R. 16(2): 121–144, 1932. These two, together with the present paper, constitute Insect Pest Survey reports for the three years covered by them. During this time the writer was acting as an official Collaborator of the Insect Pest Survey of the United States Bureau of Entomology.

Altho this third and last report by the writer includes notes on the occurrence and status of more insects on more food plants than the others, it still does not pretend to present anything like a complete picture of the activities or occurrence of even all of the more important injurious insects of the leading economic plants of the Island. Desirable as such a record would be, especially if followed out from year to year, it is impossible of accomplishment without the expenditure of much more time and money for travel and a greater number of competent observers than we have so far been able to obtain.

The accumulating, recording and arranging of even so comparatively few observations has necessitated the active help of a number of specialists. Most of the determinations or verifications of species unknown or doubtful to the writer have been made by the several well-known taxonomists at the U. S. Bureau of Entomology. In most cases this is indicated along with the individual records, as are also the names of certain other specialists not officially connected with the Bureau. The writer is indebted to Mr. Richard Faxon and his associates Messrs. Mills, Anderson, Harley and Oakley of the San Juan office of the Federal Plant Quarantine and Control Administration. All of these have obtained many records thru their official observations. The identifications of this material are by the special-

ists in Washington. The names of collectors or observers are indicated for the most part by their initials as follows:

C.G.A. = Anderson	R.G.O. = Oakley
R.F. = Faxon	A.S.M. = Mills
A.G.H. = Harley	F.S. = Seín, Jr.
M.D.L. = Leonard	G.N.W. = Wolcott

Dr. W. T. M. Forbes of Cornell University has assisted in completing the notes on some of the Lepidoptera heretofore little known as far as published records were concerned. Prof. C. R. Crosby also of Cornell, has given much appreciated help in facilitating the preparation of the manuscript for publication.

ALFALFA

Dichomeris piperatus Wlsm., an alfalfa leaf-tyer, was destructively abundant during July at Isabela, rendering the alfalfa unfit for feeding in one patch (G.N.W.). In August the leaf-tyer was found to be rather badly infesting a small experimental patch at Maleza in the municipality of Aguadilla; this is in a rather isolated section containing many hat palms and little farming has been done there; the occurrence of the insect here in injurious numbers at some considerable distance from the only other nearest alfalfa grown at the Isabela Sub-station again raises the question as to what the natural leguminous food-plant really is (G.N.W.).

Prodenia ornithogalli Guen., the velvety cutworm, was abundant during July at Isabela attacking a wide variety of hosts including alfalfa, crotalaria and tomatoes, besides numerous weeds (G.N.W.).

Thermesia gemmatilis Hüb., the velvet bean caterpillar, was abundant on the leaves of alfalfa and sword beans at Isabela during July (G.N.W.).

Reuteroscops uvidus Dist., A Mirid bug (H. G. Barber det.) was reported as infesting in small numbers the leaves and flowers of alfalfa at the Demonstration Farm at Arecibo on June 7 (C.G.A.). It was also collected by sweeping weeds at Santurce, June 29 (C.G.A., H.G.Barber det.).

ALGARROBO (*Hymenaea Courbaril* L.)

Myelois decolor Zell. (Pyralidae, C.Heinrich det.). 4 larvae found in 1 out of 6 pods examined at the Demonstration Farm at Arecibo on Mar. 8 (C.G.A.). Not in Wolcott's "List."

Stephanoderes buscki Hopk. (Scolytidae, M.W.Blackman det.) heavily infesting 6 pods examined at the Demonstration Farm at Arecibo on Mar. 8 (C.G.A.). Not in Wolcott's "List."

ANNONA SPP.

Saissetia hemispherica Targ. (Morrison det.) lightly infesting the leaves of a corazón tree (*A. reticulata*) at Corozál, Feb. 9 (C.G.A.).

Bephrata cubensis Ashm., a Eurytomid, (Muesebeck det.) infesting 1 out of 4 fruits examined at Villalba, Oct. 27 (C.G.A.).

Pseudococcus nipae Mask. (Morrison det.) lightly infesting the foliage of a tree at Corozál, Feb. 9 (C.G.A.).

Pseudoaonidia articulatus Morg. (Morrison det.) 3 out of 14 fruits infested at Ponce, Jan. 8 (R.G.O.).

Empoasca n. sp. related to *minuenda* Ball (P.W.Oman det.) breeding in moderate numbers thruout the year on the foliage of 4 trees of *A. diversifolia* at the Station grounds at Río Piedras (M.D.L.).

Patara albidula Westw. (Fulgoridae, P.W.Oman det.). A few adults on the leaves of the above trees, May 20 (A.S.M.).

?Hyaliodes n. sp., (Miridae, H.H.Knight det.) bred more or less continuously thruout the year on the foliage of the 4 *Anona diversifolia* trees at the Station; both adults and nymphs in all stages could always be found in small to moderate numbers upon examination of the leaves; the nymphs are whitish and somewhat powdery in appearance; the eggs are undoubtedly inserted in the leaf petiole or in the mid-rib but a search was not made to determine this point. The insect was also noticed thruout the previous year which was the first time it had been reported from Puerto Rico.

AVOCADO

Pseudococcus nipae Mask. (Morrison det.) so badly infested the leaves and twigs of a small tree at Mayagüez on Dec. 12 that it was practically dead (A.G.H.).

Empoasca minuenda Ball (P.W.Oman det.) A moderate number of adults and nymphs found feeding on the leaves of a tree at Santurce on Mar. 1 (A.S.M.).

BANANA

Cosmopolites sordidus Germ., the banana root-weevil, has apparently been about as injurious as during the past year. It of course also affects plantains to which it often seems to do somewhat more damage than to bananas.

Telephanus pallidulus Chevr., a Cucujid, (W.S.Fisher det.). 1 adult was found in a decayed flower-stalk at Bayamón, May 15 (C.G.A.).

Bothriocera venosa Fowl., (P.W.Oman det.) a Fulgorid; small number of adults found on the leaves of 5 plants at Bayamón, Apr. 8 (C.G.A.).

Homophysa dolotalis Möschler (W. Schaus det.). A small number of adults of this Pyralid on the 5 plants mentioned above. It was also taken at light in Bayamón, May 15 (Schaus det., C.G.A.). Apparently previously recorded only from the type material, but Dr. Forbes found the species common and apparently general in 1930.

Bean (Lima & String)

Tetranychus sp., a mite (H.E.Ewing det.), was found infesting the leaves in most lima bean fields at Loíza examined during January; a few of the leaves had turned yellowish but the damage was only slight (A.S.Mills).

?*Hyaliodes* n. sp. a Mirid (H.H.Knight det.) generally distributed during the end of August in moderate numbers on the underside of the leaves of a small patch of pole limas at the Station in Río Piedras; no nymphs were present; adults also on a small adjoining patch of okra. Both plants were only 25–30 yards away from 4 *Anona diversifolia* trees on which the bugs were breeding.

Agromyza inaequalis Mall. a bean leaf-miner (C.T.Greene det.) infesting with blotch mines practically all the leaves in a small garden patch of limes in Río Piedras, Jan. 15 (R.F.). Blotch mines in bean leaves have been observed in various places thruout the year in moderate numbers and it is presumed that they are made by this species.

Aphis rumicis L. in considerable numbers on a small patch of pole limas at the Station at Río Piedras early in Sept. (M.D.L.) and lightly infesting a 2-acre patch of limas at Loíza, Nov. 6 (A.S.M.; P.W.Mason det. both records).

Megoura viciae Kalt., an aphid (P.W.Mason det.) lightly infested lima bean pods near Río Piedras Feb. 26 (R.F.). Apparently not previously reported from P. R.

Myzus probably n. sp., an aphid (P.W.Mason det.) moderately infesting a patch of string beans at Adjuntas, Mar. 21 (R.G.O.).

Pseudococcus virgatus Ckll. (Morrison det.) lightly but generally infesting a small patch of pole limas at the Station at Río Piedras Sept. 8 (M.D.L.) and lightly infesting the pods of limas at Loíza, Mar. 14 (A.S.M.).

Agallia albidula Uhler, a leafhopper (P.W.Oman det.) lightly infested the leaves of lima beans, cassava melon and tomatoes at Loíza, Nov. 6 (A.S.M.).

Thyantor perditor Fab., a Pentatomid (H.G. Barber det.). Adults in moderate numbers on the leaves of a 3–acre lima bean patch at Loíza, Feb. 7 (A.S.M.).

Lachnopus curvipes Fab., (L.L.Buchanan det.). Several adults of this weevil found resting on plants in a 1-acre patch of limas at Vega Baja, Nov. 24 (A.S.M.).

Laphygma frugiperda A&S. (W. Schaus det.) lightly infested the pods in a 1-acre patch of limas at the Substation at Isabela, Jan. 12 (C.G.A.).

Phytometra oo Cramer, a Noctuid (W. Schaus det.), lightly infested a small garden patch of limas at Río Piedras, Jan. 15 (C.G.A.).

Nezara viridula L. (H.G.Barber det.) moderately infesting the leaves and pods in an acre of limas at Río Piedras, Dec. 12 (A.S.M.); *Nezara viridula* L. occurred in small numbers of adults on the leaves of a 3-acre patch of lima beans at Loíza, Feb. 7 (A.S.M., H.G.Barber det.).

Ellipes minuta Scudder, a Gryllid, (A.N.Caudell det.) found on a lima bean leaf in a small patch at Vega Baja, Nov. 24 (A.S.M.).

Cycloneda limbifer Csy. (E.A.Chapin det.) on a leaf in a small patch of limas at Río Piedras, Jan. 16 (A.S.M.).

Carpolonchaea pendula Bezzi (Sapromyzidae, Aldrich det.). A few larvae, from which adults were reared, in the pods in a hamper of limas at Isabela, Mar. 24 (C.G.A.). Apparently new to P. R.

Callosobruchus chinensis L. (H.S.Barber det.) found in small numbers in lima beans grown in Ponce, and kept in the office, May 25 (R.G.O.). See also under "Miscellaneous."

Corythucha gossypii Fab. was apparently generally distributed and more or less injurious to lima and string beans as usual thruout the year.

Empoasca fabalis DeL., the common bean leafhopper was generally distributed and present in its usual numbers thruout the year, often doing much damage to plantings during the drier periods, especially where they were unsprayed.

Lamprosema indicata Fab, the bean leaf-webber, was undoubtedly more or less injurious wherever beans were grown; it moderately infested pole limas at the Station during July and August but seemed to increase somewhat so that it was often doing considerably injury to all lima bean fields examined in Nov., Dec. and Jan. at Río Pie-

dras, as well as at Vega Baja, Loíza and Isabela. The moths were fairly common at light Sept. 25–27 at Puerto Real, Vieques Id. (M.D.L.).

Larvae of a Eulophid, *Grotiosmyia nigricans* How. (Muesebeck det.) found feeding on larvae of *Lamprosoma indicata* F. at Río Piedras on Jan. 15 (C.G.S.). Apparently not before recorded from Puerto Rico.

Goniurus proteus L., the bean leaf-roller, was also general but observations would indicate only light to moderate damage to limas at Río Piedras, Cidra (1 larva out of 100 plants examined by Mills) and Loíza.

Ceratoma ruficornis Oliv., a bean leaf-beetle, was present to some extent in a number of fields examined; it was reported as moderately infesting a 2-acre field of limas at Loíza on Jan. 8 and lightly infesting a 1-acre field at Río Piedras on Jan. 1 (A.S.M.).

Diabrotica graminea Baly, was undoubtedly general thruout the year as has been the case the past few years; it did considerable damage to the blossoms and leaves of pole limas at the Station and was reported as doing considerable damage also to snap beans at Orocovis on Feb. 2 by Mills.

Bean pod-borers. The comparative abundance of the 3 lepidopterous pod-borers most commonly found in lima and string beans was somewhat different than during the previous year. A report prepared by Messrs Faxon and Mills of the P.Q. & C.A. office in San Juan, altho it covers primarily the shipping season for green beans to the States—Nov. 1 to Mar. 31—fairly well summarizes the situation for the period of the whole fiscal year; it is as follows:

"*Fundella cistipennis* was usually present in small numbers in lima beans that were being shipped to the States. In previous seasons *Etiella zinckenella* Treit. appeared to be more prevalent than Fundella, but this season the situation was reversed as Fundella larvae were found to be more frequently in the pods of lima beans than either *Maruca testulalis* Geyer or *Etiella zinckenella.* The infestations of *Fundella cistipennis* were light, the highest being 3 per cent found in a hamper from Isabela. It was found to be present in shipments from Loíza, Vega Baja, Arecibo, Isabela and Adjuntas. Fifteen collections were forwarded to Washington for determination and many more could have been sent from other shipments. *Etiella zinckenella* was found only in 3 shipments of lima beans and 4 of gandules (pigeon peas)."

"*Maruca testulalis* was difficult to find until January, 1932 and the later infestations in lima and string beans and gandules were

usually light. This was particularly true of gandules as only one interception was made in cull pods at Arecibo, altho hundreds of boxes were shipped to the States. Practically the only serious infestation in lima beans was found at Cidra, Feb. 26, where 11 per cent of the pods in a 3-acre field of bush limas were infested with Maruca larvae. Sixteen collections were sent to Washington for determination from beans grown at Loíza, Río Piedras, Vega Baja, Arecibo, Isabela, Cidra and Cayey."

It is interesting to note that only 1 moth of *Etiella zinckenella* was taken by the writer during three nights of collecting at light at Puerto Real, Vieques Id., Sept. 25–26, year.

An adult of *Microbracon thurberiphagae* Mues. (Muesebeck det.) reared from a larva found on a larva of *Maruca testulalis* Geyer in a hamper of lima bean pods from Vega Baja, Mar. 24 (C.G.A.). Three larvae of this parasite were also found infesting 1 out of 20 larvae of *Maruca testulalis* in lima bean pods at Cidra, Feb. 2 (A.S.M.). The first record for Puerto Rico; Bruner has recently recorded it from Cuba from the same host.

Beet

Disonycha laevigata Jacoby was observed lightly infesting a small patch of beets at Jayuya on June 14 (R.G.O.) but was undoubtedly generally distributed and injurious as usual to beets, swiss chard and related crops. (See also "Micellaneous").

Bidens pilosa radiata

Thrips abdominalis in moderate numbers in the flowers at Río Piedras on May 31 (A.S.M.; J.R.Watson det.).

Protalebra brasiliensis DeL., known to be a minor pest of sugar cane, continued to be abundant thruout this past year as during the previous one on all patches of the weed at El Morro in San Juan. It seemed to be very scarce if at all present at the Station in Río Piedras on the same food-plant.

Books

Rhizopertha dominica Fab. (*R. pusilla* Fab. is a synonym, A.J. Mutchler det.) according to Dr. Wm. A. Hoffman has done considerable damage to the books in the library of the School of Tropical Medicine thruout the year and for a couple of years previous. It is a cosmopolitan Bostrychid beetle injurious to lumber.

Bougainvillia

Orthesia insignis Douglas was reported as badly infesting a large vine at a home in Santurce on Apr. 20 and on Apr. 22 specimens were received from Bayamón with the statement that an unidentified tropical ornamental was rather badly infested.

Cabbage

Plutella maculipennis Curtis, the diamond-back moth, was observed in a number of places and was presumably as common and injurious as formerly.

A slug, *Veronicella occidentalis* Guilding, reported as doing considerable damage to cabbage, but also eating holes in green tomato fruits in a 1-acre garden planting at Trujillo during April.

Corythaica planaris Uhl., the eggplant lace-bug, was found in small numbers, adults, in a planting at Ponce on May 14 (R.G.O., H.G.Barber det.).

Cacara tuberosa (Lam.) Britton

Alysia analis Cress. was found on several plants at Ponce on June 28 (R.G.O., Muesebeck det.).

Canna

Calpodes ethlius Cramer, the canna leaf-roller, became destructively abundant during July on a number of plants at Isabela, averaging 1 or 2 larvae per plant (G.N.W.); it was observed in several other localities also.

Frankliniella insularis Franklin. See under "Rose" for note on damage to canna blooms.

Carrot

Systena basalis Duv. was observed in large numbers on the leaves in a 1/10-acre planting at Jayuya on June 14 (R.G.O., H.S.Barber det.).

Cashew nut (*Anacardium occidentale* L.)

Selenothrips rubrocinctus Giard, the red-banded thrips, defoliated several trees at Río Piedras in September and was again observed infesting the new foliage on the same trees the following February; in April a tree in another place near Río Piedras was badly infested (F.S.).

Cassava

Saissetia oleae Bernard so badly infested several considerable sized plantings from 6 months to 1 year old at the Manicomio near Río Piedras the latter part of July that many of the plants were entirely devoid of leaves and in a dying condition; several branches submitted for identification were badly encrusted with the scales in all stages of growth (S.Molinary).

An unidentified *whitish scale* was also present in the above infestation but apparently not as abundant as the other altho one of the branches brought in was badly infested.

Lonchaea chalybea Weid., the cassava shoot-borer, was received under date of Oct. 2 from the Agricultural Agent at Bayamón who stated that for some little time the insect had been very common in all the plantings in the district and had considerably reduced the yield.

Cryptosephalus tristiculus Weise, a Chrysomelid, (H.S.Barber det.), was found, 1 adult, on a leaf of one plant Apr. 29 (C.G.A.) at Lares.

Aphodius lividus Oliv. was found, 2 adults, on a plant at Santurce on June 29 (C.G.A., H.S.Barber det.).

Red-spiders, *Tetranychus* sp., were more or less injurious as usual, especially during the drier periods.

Cassia siamea

Asterolecanium pustulans Ckll. was observed to be badly infesting several ornamental trees at the Director's home on the Station grounds on May 6 at Río Piedras (F.S.).

Castor Bean

Corythucha gossypii Fab. was more or less abundant on nearly all plants observed in various parts of the Island thruout the year as is usual.

Casuarina equisetifolia Forat

This tree which is widely grown in Puerto Rico as an ornamental and as a wind-break for citrus had heretofore been considered as practically if not entirely immune from insect attack in the Island. Continued obseration has finally disclosed the following insect pests:

Icerya purchasi Mask., the cottony cushion—scale was first found in very small numbers in Santurce in October but during the late winter and spring and early summer it became generally distributed

and often injurious on ornamental casuarina trees and hedges thruout San Juan and Santurce south to at least Martín Peña and also infested wind-breaks in several citrus groves in Palo Seco, Bayamón and Dorado.

Icerya monserratensis R.& H.,another mealy bug which has been long known to infest *Ficus nitida* or West Indian Laurel (which see) in Puerto Rico was brought in on April 10 by Edumudo Martínez of the Insular Forest Service as moderately infesting all the casuarina trees in the Plaza at Cayey. He stated that there had been some rain there recently and that the insects were apparently somewhat less numerous than at a previous inspection about 3 weeks or a month ago.

Howardia biclavis Comstk. (Morrison det.) was found infesting a number of trees at the Scoville place on the Carolina road near Río Piedras (G.N.W.); it was also collected in moderate abundance on several small trees at the Forest Service Station at Río Piedras on Mar. 29 (M.D.L.).

Hemichionaspis minor strachani Cooley (Morrison det.) was also collected from one tree lightly infested at the Forest Service Station on Mar. 29 (M.D.L.).

Diaprepes spengleri L. adults were observed in considerable numbers in copula and aparently feeding to a slight extent on a hedge near San Juan on May 7 (M.D.L.).

CEDRO HEMBRA (*Turpinia paniculata* Vent.)

Hypsiphila grandella Zell., a lepidopterous shoot-borer (Heinrich det.), was reported on June 11 as injuring to a considerable extent about 4,000 trees planted among coffee for shade at Jayuya and on June 29, 1931, 1,000 young trees recently planted in a coffee finca at Adjuntas. In mid-July F. Seín Jr. reported that a number of young trees were moderately infested in the Rural School planting in Lares. This pest was also generally present and badly skeletonizing these shade trees in another large coffee finca (Hacienda Carmelita) in the general vicinity of Adjuntas in September.

CELERY

A mealy-bug, presumably *Pseudococcus citri* Risso, was found on July 2 to be moderately infesting several plants (one badly infested) at the Station grounds in Río Piedras. The bugs were clustered at the base of the plants just above the ground and a few were on the roots. There is only one previous record for celery in Puerto Rico —collected by T. H. Jones, July 3, 1912, Río Piedras, Morrison det.

Chalcas exotica

Coccus viridis Green, the green scale, was observed on the leaves and twigs of one bush at Vega Baja on Dec. 29 (R.F.).

Chayote

Margaronia nitidalis Cr. 2 larvae in a crate on Feb. 26 for shipment to the States (C.G.A., Schaus det.).

Chick pea

Rhizopertha dominicana Fab., a Bostrychid beetle, was found infesting about 10 per cent of the peas in a small package in Santurce on Nov. 11 (R.G.O., W.S.Fisher det.).

Cephalonomyia gallicola Ashm., (Muesebeck det.) was lightly infesting a package the same package (R.G.O.). Not in Wolcott's "List".

Chocolate

Oryzaephilus surinamensis L., the saw-toothed grain beetle, was found, several adults, larvae and pupae, in the chocolate coating of candies from Switzerland via New York about a year previous (A. S.M., Fisher & Boving det.).

Laemophlaeus minutus Oliv. (Fisher det.). An adult on chocolate cake in a restaurant in San Juan, June (C.G.A.).

Chrysobalanus icaco L.

Nessorhinus vulpes A. & S. (Membracidae, P.W.Oman det.). A few adults on the stems of hicaco at Arecibo, May 20 (C.G.A.) Not in Wolcott's "List".

Citrus

Icerya purchasi Mask., the cottony cushion-scale, was first discovered in considerable abundance on a number of grapefruit trees in a large grove at Palo Seco on April 2. Continued search from then on to the end of June discovered infestation in grapefruit groves in Bayamón and Dorado, 6 in all, and on many ornamental citrus trees thruout San Juan and Santurce south to at least Martin Peña. In 3 or 4 of these groves the infestation developed rapidly to considerable proportions but it was largely checked by the end of the year by spraying, native natural enemies and the prompt introduction of the Australian or Vedalia ladybeetles. The most efficient and widespread parasite was a Phorid fly, *Syneura cocciphila* Coq.,

which was present in nearly every infestation found on all food-plants, often killing as high as 50 per cent of the insects in large individual colonies. Other natural enemies were the lace-wing fly, *Chrysopa collaris* Schneider, the common Coccinellid, *Cycloneda sanguinea* L. and often where well-established dense colonies were present the scavenger and scale-feeding caterpillar, *Ereuntis minuscula* Wlsm. Food-plants other than citrus were: Australian pine, *Casuarina equisetifolia;* rose; gallego, *Polsias guilfoylei;* gallito, *Agati grandiflora;* pigeon pea; María, *Callophyllum antillanum;* and Acalypha sp.

Asynapta citrinae Felt an Itonid cambium miner found in July in grapefruit twigs at Isabela; the pink maggots formed cocoons in the soil on July 11 and 2 adults emerged on July 15 (G.N.W.).

A snail, as yet undetermined, of small size, skeletonized the leaves in a seed-bed of several thousand grapefruits at the experimental plantings at Trujillo Alto the end of August; the seedlings were not more than 6 ins. high and were generally infested, about 5 per cent being killed before control measures could be applied (E.H. Twight).

A mite, *Uropoda* sp. (H.E.Ewing det.) found infesting the skin of 1 out of 50 grapefruits examined at Mayagüez on Jan. 22 (A.G.H.).

Catyclysta miralis Möschler (Wm. Schaus det.) a Pyralid moth taken on a kumquat leaf at Río Piedras Mar. 15 (A.S.M.).

Lachnopus curvipes Fab., a weevil, was reported by Dr. Wolcott to be locally more abundant around Isabela during July than the common "vaquita", *Diaprepes spengleri,* which causes the bulk of the injury to citrus foliage. A small number of adults were found on grapefruit leaves at Barceloneta on May 10 and a few eating the leaves in a grove at Vega Alta on May 15 (C.G.A.).

Diaprepes spengleri L. and its varieties was about as abundant, with local variations, as usual thruout the citrus section, doing considerable damage to foliage and often causing very young fruits to drop by cutting them off at the stem attachment. In general the season of greatest abundance of adults was apparently April or May into June or July. Dr. Wolcott reported that in September adults were less abundant at Isabela and only 1 or 2 egg-clusters could be found after several hours search on a certain day, whereas many were found toward the end of August in the same place in a much shorter time.

Exopthalmodes roseipes Chev., the "vaquita verde" beetles were present during the spring and early summer as usual doing injury

to citrus foliage; they were observed as especially abundant in May in several grapefruit groves in Palo Seco, Manatí and Vega Alta.

Blossom thrips were common in various parts of the citrus section during a considerable blossoming period from April into May. Specimens were identified by J.R.Watson as *Frankliniella difficilis* Hood and *F. insularis* Fkln. The latter is the common black blossom thrips thruout the West Indes. *F. cubensis* Hood, a yellow species, was also apparently involved. It should be here noted that the writer overlooked in a note on citrus thrips in Puerto Rico (Jour. Econ. Ent. 25(4): 934–935, 1932) that Dozier had listed *F. tritici* Fitch as taken in grapefruit blossoms at Trujillo Alto (Jour. Dept. Agr. P. R. 10(3&4): 280, 1926, issued 1927).

Papilio androgeus Cr., the orange dog, was reared to adult on July 12 from a caterpillar found on grapefruit foliage sometime previous in Isabela; 2 other caterpillars brought in on the 12th (G.N.W.).

Corythucha gossypii Fab. was observed in several places from time to time infesting both grapefruit and lime and citron foliage but more abundant and actively breeding on the last especially at Palo Seco and Río Piedras.

Fecelia minor Voll. (Pentatomidae, H.G.Barber det.) adults found in small numbers on the fruit in an orange grove near Ponce and in two groves near Peñuelas on Jan. 25 and on March 8 (R.G.O.). Adults were very prevalent during January and February in the Ponce district on wild oranges causing about an 8 per cent loss of fruit. Not in Wolcott's "List."

Dialeurodes citrifolii Morg., the cloudy winged whitefly, heavily infesting the leaves of two lime trees at Ponce on April 8 (R.G.O., Morrison det.).

Pseudococcus citri Risso, the citrus mealybug, was observed to be fairly common on the larger branches of grapefruit trees in several groves in the eastern part of the citrus section.

Piezosternum subulatum Thunb. (Pentatomidae, H.G.Barber det.). 1 adult on a grapefruit leaf at Bayamón on June 12 (C.G.A.).

Toxoptera aurantii Boyer was moderate to abundant on new growth during the spring in grapefruit in several sections, being especially noted at Arecibo, Bayamón and Manatí.

Aphis gossypii Glov., the melon aphid, heavily infested the tender shoots and leaves of many young grapefruit trees at Añasco on Jan. 27 (A.G.H., P.W.Mason det.). Apparently the first record of injury to citrus in Puerto Rico.

Aleurothrixus howardi Quaint. (G.B.Merrill det.) was observed in moderate numbers on grapefruit leaves on several trees in a large grove in Palo Seco during April and on one tree in a grove at Toa Baja in May (A.S.M., M.D.L.).

Eugnathodus guajanae DeL. (Cicadellidae, P.W.Oman det.) an adult on a grapefruit leaf at Bayamón, May 15 (C.G.A.).

Dikraneura (*Hyloidea*) *depressa* McAtee (Cicadellidae, P. W. Oman det.) in small numbers, adults, on several grapefruit trees at Arecibo, Apr. 5 (R.F.). Not in Wolcott's "List."

Empoasca minuenda Ball (Cicadellidae, P.W.Oman det.) present in small numbers as adults on grapefruit leaves in a grove at Arecibo on Apr. 5 (C.G.A.). Not in Wolcott's "List."

Ormenis infuscata Stål (Fulgoridae, P.W.Oman det.). Several adults on grapefruit leaves at Arecibo, Apr. 5 (C.G.S.).

Ormenis quadripunctata Fab. (Fulgoridae, P.W.Oman det.) a few adults on grapefruit leaves at Bayamón on Apr. 8 (A.S.M.).

Delphacodes sp. probably new (Fulgoridae, P.W.Oman det.)—an adult on a grapefruit leaf, Bayamón May 15 (C.G.A.).

Ecpantheria icasia Cram. (Arctiidae, Schaus det.)—an adult reared from a larva on a grapefruit leaf, Bayamón, May 15 (C.G.A.).

Edessa cornuta Burm. (Pentatomidae, H.G.Barber det.) in small numbers as adults on grapefruit leaves on several trees at Bayamón on Apr. 15 (C.G.A.).

Rhaptinus torquatus Oliv. (Curculionidae, L.L.Buchanan det.) in small numbers on grapefruit leaves at Las Marías, May 3 (C.G.A.).

Brentus volvulus Fab. (Brentidae, L.L.Buchanan det.) adults found on grapefruit blossoms at Mayagüez, May 17 (A.G.H.).

Chionaspis citri Comstock, was common to abundant on the trunks and larger branches of many grapefruit trees examined during April and May in groves at both Palo Seco and Bayamón; a considerable percentage of the male scales had parasite emergence holes.

Ceroplastes floridensis Comstock, the wax scale, was present in small numbers on a few grapefruit trees in a grove at Palo Seco and was also observed in one or two other places in the eastern part of the citrus section.

Anastrepha sp. the west Indian fruit-fly was found lightly infesting a few grapefruits in one grove near Mayagüez and in two groves near Arecibo in April.

Coconut

Aspidiotus destructor Sign., the coconut scale, was reported by F. Méndez, Coconut Specialist at the Station, as being not nearly so

abundant at Cabo Rojo in September as it had been 5 or 6 months previously. On Sept. 26, as far as could be observed practically every coconut palm on Vieques Island was more or less infested, those towards the eastern and drier end of the Island especially so, many palms having a sickly and yellow appearance and in some cases even the fruits were encrusted with the scales.

Coffee

Leucoptera coffeella Staint., the coffee leaf-miner, was generally distributed and quite abundant thru the whole of the Hacienda Carmelita, a large coffee farm in the vicinity of Jayuya, visited Sept. 9–10 but apparently not much damage was being done to bearing trees. According to Vicente Medina, Coffee Specialist at the Insular Experiment Station, the leafminer was more abundant during Dec. and Jan. than the two previous months due to generally dry weather thruout the coffee growing regions.

Coccus viridis Green, the green scale, was general tho not very abundant thruout the Hacienda Carmelita on the visit referred to above, the younger shoots and leaves being more infested than older parts, as is usual.

Psychonoctua personalis Grote, a Coffee stem-borer was received under date of Sept. 29 in injured branches from the Agr. Agent at Corozal with the statement that considerable damage was being done by the hollowed-out branches being broken off when they were bent down by the pickers.

Apate francisca Fab., a coffee stem-borer, was reported by Vicente Medina of the Station staff as damaging some trees on a farm at Adjuntas on April 18.

Psyllia minuticona Cwfd. present in small numbers as adults on coffee leaves at Adjuntas April 14 (R.G.O., P.W. Oman det.).

Bothriocera venosa Fowl. (Fulgoridae, P.W.Oman det.), in small numbers as adults on coffee leaves at Adjuntas, April 14 (R.G.O.).

Scymnillodes gilvifrons Chpn. (Nitidulidae, E.A.Chapin det.) on coffee leaves at the Torres finca at Adjuntas, April 14 (R.G.O.). Not in Wolcott's "List."

Psorolyma maxillosa Sic. (Coccinellidae, E.A.Chapin det.) in small numbers on the leaves out of 30 plants examined at Utuado on May 17 (R.G.O.).

Corn

Heliothis obsoleta Fab, the corn earworm, infested practically every ear of sweet corn at Isabela during September (G.N.W.); the

ears in 4 boxes of corn from Añasco examined Mar. 7 were heavily infested (A.G.H.).

Diabrotica graminea Baly was abundant and injurious to corn at Isabela during July (G.N.W.).

Disonycha laevigata Jacoby present in large numbers on corn leaf-sheaths at Loíza on April 11 (C.G.A.).

Peregrinus maidis Ashm. adults common on leaf-sheaths of several plants at Loíza Apr. 11 (C.G.A.).

Solubea pugnax Fab., (H.G.Barber det.) in small numbers as adults on corn leaves at Jayuya on May 14 (R.G.O.).

Orius (*Triphleps*) *insidiosus* Say (Anthocoridae, H.G.Barber det.) adults common on leaf-sheaths of several plants at Loíza, Apr. 14 (C.G.A.).

Laphygma frugiperda A. & S. moderately infesting corn ears at Loíza, Apr. 11 (C.G.A.).

Oscinella coxendix Fitch. (J.M.Aldrich det.) common on leaf-sheaths of several plants at Loíza, Apr. 11 (C.G.A.). This species is little-known in Puerto Rico.

Cotton

Pectinophora gossypiella Saund., the pink bollworm, was much less injurious to this past year's crop than to that of the previous year; the explanation for this is not clear. The clean-up, altho not carried out as thoroly as had been hoped for on the crop remnants from the previous season, might have been responsible for some reduction in the pink bollworm population. The acreage in cotton was greatly reduced, however, especially in the South Coast and theoretically there should have been a greater infestation. As an example of the reduced infestation it may be stated that as late as Jan. 20 J. Pastor Rodríguez, Cotton Specialist at the Station, reported a 1-acre field in the South Coast, which last year had been very badly infested, to show less than 1 per cent of the bolls infested and a nearby field only about 5 per cent. (For a more complete account of conditions covering the infestation of the previous crop thru picking into the fall of 1931 on the North Coast see Leonard in Jour. Dept. Agr. P. R. 16(1): 65–73, 1932).

Alabama argillacea Hübner, the cotton leaf-worm, was also much less numerous and injurious than during the previous crop; it was, in fact, practically negligible; two small outbreaks were reported from the South Coast during the latter part of December and the middle of January but these were easily controlled by two applications of poison. During July (on the previous crop) it was destruc-

tive thruout the whole North Coast but most injurious around Isabela and Camuy; during August the attacks naturally abated on the North coast due largely to the fact that most of the plants by that time were old and no longer succulent. According to F.E.Rorke of the San Juan Ginnery at least 80–85 per cent of the crop had been picked by the end of August in the North Coast but the leaf-worm continued active until at least the middle of the month around Manatí and apparently there was a certain amount of leaf-worm feeding in several other localities.

Dysdercus spp., mostly *D. andreae* L, the common cotton stainer, with occasionally undoubtedly a slight intermixture of *D. neglectus* Uhl. were more or less abundant on cotton bolls as usual, especially during the end of the crop, but altho they are responsible for some staining of the lint no attempt has been made to estimate how much damage is done.

Empoasca sp. leafhoppers were always to be found as usual in small to moderate numbers in all stages on the plants. Altho the Puerto Rican specimens have never as yet been specifically determined they probably belong to *E. gossypii* DeL described from Haiti in the April 1932 number of this Journal.

Nepticula gossypii Fbs. & Leon., the cotton leaf-miner, was present apparently in about the same numbers on the South Coast as during the previous year but as before was not observed to occur in the North Coast.

Ephestia cautella Wlk. (Pyralidae, Heinrich det.). A few adults observed on several tons of cotton seed cake at the Ginnery at Hato Rey on Mar. 9 (A.S.M.); an adult was also taken on a sword-bean leaf at Arecibo on Mar. 8 (C.G.A.).

CROTALARIA

Utethesia ornatrix L., the rattlebox moth, was reported as very abundant by Dr. Wolcott the middle of Oct., the caterpillars searching for food in great numbers on the beaches at Isabela; the moths were also common at lights at Isabela. This species was more or less injurious as usual to Crotalaria grown for seed thruout the Island.

Nezara viridula L. was present in large numbers, both as nymphs and adults, on the leaves and pods on the Preston farm at Naguabo on June 3 (C.G.A., H.G.Barber det.).

Nezara marginata P. de B. Many specimens clustered on a single pod at Isabela in July (G.N.W.).

Delphacodes teapae Fowl. (Fulgoridae, P.W.Oman det.). A few adults on the leaves at the Preston farm at Naguabo on June 3 (C.G.A.).

Cucumber and Melon

Aphis gosspii Glov. was troublesome to cucumbers at the Station during July necessitating frequent spraying. It also heavily infested a 2–acre planting of cassava melons at Loíza in January (A.S.M., P.W.Mason det.). It was undoubtedly general and injurious as usual.

Diabrotica graminea Baly (H.G.Barber det.) was doing light damage on a 2-acre planting of squash at Vega Alta on Nov. 24 (A.S.M.).

Diabrotica innuba Fab., a leaf-beetle, was quite abundant on cantaloupes at Isabela in July (G.N.W.).

Diaphania hyalinata L., the melon worm, was observed the end of July to be considerably injuring the leaves and blossom-buds of a fair-sized patch of cucumbers at the Station at Río Piedras; the vines were just beginning to run and no fruit had set as yet. It necessitated spraying almost every other day during August. On Jan. 4 it was observed doing considerable damage to young cassava melon vines at Loíza; moderate damage observed on squash vines at Vega Alta in Nov. and to cucumber at Manatí in January; in a well sprayed field of cucumbers, however, at Barceloneta only slight damage was being done (A.S.M.).

Nezara viridula L. lightly infested squash leaves in a 2-acre field at Vega Alta, Nov. 24 (A.S.M.).

Margaronia nitidalis Cr., the pickle worm,—a single larva found in a fruit while examining a crate offered for shipment; the adult was reared (A.S.M., Schaus det.).

Agallia albidula Uhl. (P.W.Oman det.) lightly infested cassava melon at Loíza, Nov. 6 (A.S.M.).

Argyria diplomachalis Dyar (Pyralidae, Wm. Schaus det.) one adult resting on a cucumber leaf at Loíza, Mar. 14 (A.S.M.). Only one previous published record—"on weeds and at light" Río Piedras, 1916.

Dasheen

Atherigona orientalis Schiner (Anthomyidae, Aldrich det.) maggots were found infesting 1 root out of 10 examined in the Public Market in San Juan on Mar. 30 (C.G.A.). Apparently not previously listed from P. R.

EGGPLANT

Epitrix parvula Fab., the tobacco fleabeetle, heavily infesting 20 plants examined at Loíza on Mar. 14 (A.S.M.; H.S.Barber det.).

Myzus persicae Sulz. moderately infesting 20 plants at Loíza in March but it was injurious in other places also during the year as usual.

Lysiphlebus testaceipes Cress. Adults were numerous on eggplant leaves at Loíza, Mar. 14 where they were undoubtedly parasitizing aphids which were numerous on the plants (C.G.A.) Muesebeck det.).

Coyrthaica planaris Uhl. (= *C. monacha* Stal.) was observed moderately infesting the foliage of about 10 out of 40 plants examined at Juncos on Jan. 25 (R.F., H.G.Barber det.). Altho few definite observations were made other than this it was undoubtedly present and more or less injurious as usual.

Aleurotrachelus trachoides Back, badly infesting a number of experimental potted plants in the Station greenhouses during April.

Argyria opposita Zell. (Pyralidae, Schaus det.). 5 moths collected on eggplant leaves at Juncos, Jan. 25 (R.F.). Not in Wolcott's "List."

Kalotermes marginipennis intercepted in a shipment of egg-plants from Puerto Rico (S.R.A., P.Q. & C.A., issued March, 1932, p. 347). Not in Wolcott's "List."

FICUS SP.

Diaprepes spengleri L., adults were present in fair numbers (but less so than on the same trees last June) on several trees of a *Ficus* probably *laevigata* near Santa Isabel on August 20–22, 1931. 35 egg masses were collected with Dr. J. G. Myers during several hours hours careful search in an effort to obtain Trichogrammatid egg-parasites for introduction into Barbados. The percentage of parasitism could not to determined at the time.

GALLEGO (*Polysias Guilfoylei*)

Icerya purchasi Mask., the cottony-cushion scale, was first found infesting this plant on Feb. 26 in Santurce. During the spring gallego trees were found infested at Palo Seco and in one or two other localities.

GOMPHRENA DISPERSA Standley

Hymenia fascialis Cramer continued to be abundant on this weed at El Morro in San Juan, the larvae webbing together and skeletonizing the leaves.

GRAPE

Aphis illinoisensis Shimer, the black grape aphid, was present in small numbers on several vines in an arbor at Ponce early in March. It was also abundant on the tender shoots of a fairly large arbor at Puerto Real, Vieques Island, Sept. 8.

GRASSES

Scapteriscus didactylus Scudder, the changa, did considerable damage to the St. Augustine grass in the fairways on the golf course at San Juan during dry weather in the spring of 1932.

Cicadella similis Walker (P.W.Oman det.) adults were very abundant on mallojillo or Para grass, *Panicum barbinode*, at Bayamón, May 15 (C.G.A.).

Collaris oleosa Dist. (Miridae, H.G.Barber det.) adults numerous on Para grass at Bayamón, May 15 (C.G.A.). Not in Wolcott's "List."

Zelus subimpressus Stal (H.G.Barber det.) adults numerous on Para grass at Bayamón, May 15 (C.G.A.). Not in Wolcott's "List."

Catorhintha guttula Fab. (H.G.Barber det.) a small number of adults on grass at Ponce, June 8 (R.G.O.).

Mormidea cubrosa Dallas (H.G.Barber det.) present in moderate numbers on grass at Ponce, May 13 (R.G.O.). Not in Wolcott's "List."

Psara phaeopteralis Guen. was reported on July 8 as injurious to "gramma" grass (St. Augustine grass) at Isabela. The grass on a large lawn was worse affected in the shade than in the sun (G.N.W.).

GUAVA

Leptomastix dactylopii Howard (Encyrtidae, Muesebeck det.). A pupa found in a guava fruit infested with *Anastrepha* sp. larvae (C.G.H.). Not in Wolcott's "List."

Coccus viridis Green, the green scale, moderately infesting the leaves of two bushes at Arecibo, Feb. 23 (A.S.M.).

Lechriops psidii Marshall (Curculionidae, Buchanan & Boving det.) larvae in mummied fruits at the Atlas Fruit Co. in Bayamón, Jan. 11 (C.G.A.). Apparently the second record from P. R., the type being the first.

Ormenis infuscata Stal (P.W.Oman det.) one adult on a guava leaf at Arecibo, Jan. 26 (R.F.).

Xyleborus sacchari Hopk. (Blackman det.) reported as infesting 2 out of 10 fruits examined at Cabo Rojo, Sept. 16 (A.G.H.).

Leptoglossus stigma Hbst. (H.G.Barber det.) abundant on the leaves of 3 guava bushes at Cidra, Nov. 13 and many adults on a bush at Trujillo Alto, Oct. 23 (A.S.M.).

Argyria diplomachalis Dyar (Pyralidae, Schaus det.) adults common on several bushes at Corozal, Mar. 18 (C.G.A.).

Heterothrips sericatus Hood (J.R.Watson det.) numerous in all of the blossoms on one bush at Barceloneta, June 14 (A.S.M.)

Metachroma sp., new to U.S.N.M. (H.S.Barber det.) found in small numbers on the leaves at Río Piedras, May 31 (C.G.A.).

Pulvinaria psidii Mask. (Morrison det.) moderately infesting the leaves at Lares, April 15 (R.G.O.).

Anthonomus inovatus Dietz (Buchanan det.) one adult on a fruit at Adjuntas, Apr. 11 (R.G.O.). Not in Wolcott's "List.".

Aleurodicus (*Metaleurodicus*) *minimus* Quaintance (G.B.Merrill det.) moderately infesting the leaves of 2 guava trees on the Denton Farm at Arecibo, Feb. 23 (C.G.A.).

Ormenis pygmaea Fab. (P.W.Oman det.). Adults in small numbers on the above trees (A.S.M.) and a moderate number of adults on a coffee tree at Arecibo on Mar. 8 (C.G.A.).

Hibiscus

Frankliniella cubensis Hood and *insularis* Franklin (J.R.Watson det.) adults in flowers at Mayagüez, March 20 (A.G.H.).

Haplothrips n. sp. (Watson det.) adults in flowers at Mayagüez, Mar. 20, (A.G.H.)

Inga Spp.

Tanaostigmodes portoricensis Cwfd. (Muesebeck det.) Heavily infesting pods of Guamá, *Inga laurina*, at Mayagüez, March 24. (A.G.H.) Previously known in P. R. only from the type.

Brenthia pavonacella Clem. A leaf-skeletonizer, badly infested the Inga shade trees thruout the coffee growing regions from fall to spring.

Carpolonchaea pendula Bezzi (Aldrich det.) adults reared from *Inga laurina* fruits, 25 per cent infested, at Jayuya, Jan. 18 (R.G.O.)

Jobo (*Spondias dulcis* Frost)

Haptoncus luteolus Er. and *Urophorus humeralis* Fab. (E.A. Chapin det.). All the fruits in a small package infested at Arecibo, Oct. 29 (R.G.O.). The latter not in Wolcott's "List."

Mahogany

Saissetia oleae Bern. and *Chrysomphalus dictyospermi* Morg. (Morrison det.) Very bad on a number of young trees at Forestry Station, Río Piedras, Mar. 29.

Malay Apple (*Jambos malaccensis*)

Coccus mangiferae Green, *C. acuminatus* Sign. and *Diaspis boisduvalii* Sign. (Morrison det.). Moderately infesting the leaves of two trees near Río Piedras, Jan. 11. (A.S.M.) The last not in Wolcott's "List."

Eucalymnatus tessellatus Sign. (G.B.Merrill det.). Same as above.

Mamey (*Mammea americana* L.)

Toxoptera aurantiae Boyer (P.W.Mason det.) Young leaves heavily infested on small trees at Las Marías, Mar. 17 (A.G.H.)

Patara albidula Westw. (P.W.Oman det.). Adults common on one tree at Barceloneta, Mar. 22 (C.G.A.). Not in Wolcott's "List."

Mango

Selenothrips rubrocinctus Giard did considerable damage to the foliage of 1,000 nursery trees at the Station in August.

Asterolecanium pustulans Ckll. badly infested 3 trees at Río Piedras, Feb. 23.

Mangrove

Psychonoctua personalis Grote badly infested a large area of mangrove swamp at Pt. Cangrejos near San Juan in April. The trunks and branches down to ground level were badly tunneled in nearly all the plants. Larvae of all sizes, pupae, and empty pupal skins were present. It was cut before maturity, causing a considerable loss in the yield of charcoal.

María (*Calophyllum antillarum* Britt.)

Eucalymnatus tessellatus Sign. (Morrison det.) lightly infested one tree near Río Piedras, Feb. 17 (C.G.A.)

Pseudococcus adonidum L. (Morrison det.) heavily infested the leaves of a tree near Río Piedras, Feb. 17. Not in Wolcott's "List."

Oxacis sp. probably new (H.S.Barber det.) Adults numerous on the leaves of several trees in Santurce, May (A.S.M.)

Toxoptera aurantiae Boyer and *Aspidiotus cocotiphagus* Marl. lightly infesting the young shoots on several trees in Santurce in May. First record for this host in P. R.

Icerya purchasi Mask. was abundant during the spring and early summer on a number of trees in Santurce.

Okra

Pectinophora gossypiella Saund. was found on July 10 infesting 10 out of 16 pods examined in a 1-acre planting at Trujillo Alto. The okra adjoined a field of about 1½ acres of cotton which showed about 85 per cent infested bolls. The okra plants examined were situated near the edge of the field next to the cotton. The infested pods were all mature, at least 3 or 4 inches in length, and each contained 1 or 2 larvae and several pupae were found within the pods. The cotton was an old field which had been infested for some time. In July (A.S.M.) okra planted experimentally at Isabela with cotton was also infested.

Diabrotica gramina Baly did considerable damage at the Station during August and moderate damage in a 1-acre planting in Trujillo Alto in July.

Aphis gossypii Glover was generally present but not very injurious at the Station during July.

Corythucha gossypii Fab. was found towards the end of the month in small numbers on the okra at the Station. The okra adjoins the pole limas on which the insects were breeding very abundantly. Only adults could be found but these were feeding to a noticeable extent, causing the characteristic yellowish stippled areas on the leaves.

Hyaliodes n. sp. (H.H.Knight det.) was present in some numbers in the same planting.

Oleander

Asterolecanium pustulans Ckll., was very abundant on a number of oleanders at Guánica on March 12. A plant was also heavily infested at Old Loíza, April 29 (A.S.M.).

Palm

Pinnaspis buxi Bouché, heavily infesting a palm at Pennock's nursery near Río Piedras, Feb. 17 (R.F.; Morrison det.). Not in Wolcott's "List."

Eucalymnatus tesselatus Sign. (Morrison det.) heavily infested a palm in a nursery near Río Piedras, Feb. 17 (C.G.A.)

Pseudococcus nipae Mask. moderately infested a palm in Santurce, May 23.

PANAMA POTATO TREE

(*Solanum grandiflorum leiocarpum*)

Pseudococcus citri Risso (Morrison det.) lightly infested the leaves of 6 large trees at the Station at Río Piedras, Feb.; also 30 trees near Juncos, Jan. 25 (C. G. A.)

Pseudoparlatoria ostreata Ckll. A heavy infestation on the bark on one of the trees at Juncos.

PAPAYA

Toxotrypana curvicauda Gerst. Three medium sized fruits sent in by the Agricultural Agent at Jayuya with letter of June 1 stating that they came from a planting of about 50 trees just coming into production on the farm of Dr. Manuel Megías, Barrio Collores. All were fairly green, the 2 smaller moderate sized ones had been badly infested but the larger one was clean—only 1 or 2 dead larvae present. The papaya fruit fly was also sent in under date of July 8 by F. B. McClelland from the Mayagüez Experiment Station in a rather small and rather green fruit which contained 14 newly formed puparia and 1 full grown larvae (M. D. L.) One fruit was found infested at the substation at Isabela on July 3 and sometime during the month all of the fruit on several plants in a farm near Aguadilla were infested (G. N. W.) It was also found to be infesting the fruit of a number of plants on a farm near Ponce on Aug. 5. One fruit small and green and about 2½ inches long contained 20 larvae and another somewhat more mature and about 5 or 6 in. long contained 24 larvae; in both fruits the maggots were nearly to full-grown. The owner, Mr. Heraclio Girón, stated that during May and June nearly all of the fruits on his trees were infested, many so badly that they had to be thrown away. It was not found in several fruits cut open at the farm of Heraclio Girón near Ponce on Sept. 9. Mr. Girón stated that no infested fruits had been noticed for several weeks whereas formerly they had been heavily infested. As previously reported many infested fruits had been destroyed and I suspect that this resulted in greatly reducing the infestation in his planting.

Pseudoparlatoria ostreata Ckll. Heavily infested the fruits and stems of a papaya in San Juan, Jan. 13 (A. S. M.) It was abundant also on a number of trees in the Girón farm near Ponce, September.

Aulacaspis pentagona Targ. moderately infested the trees on the Girón farm. There was also a heavy infestation at the Isabela Substation in March.

Saissetia hemisphaerica Targ. also heavily infested the trees at Isabela.

Corythucha gossypii Fab. heavily infested the trees at Isabela during March and as is usual was observed in other places thruout the season.

Epitomiptera orneadalis Guer. (Schaus det.) A larva was found feeding on a papaya leaf, Mar. 8 (C. G. A.) Not in Wolcott's "List."

Nezara viridula L. (H. G. Barber det.). A light infestation of nymphs on papaya leaves near Río Piedras, Mar. 9 (C. G. A.).

Peas

Illinoia solanifolia Ashm (P. W. Mason det.). One winged adult was on a pea leaf at Cidra, Feb. 26 (A. S. M.) Not in Wolcott's "List."

Piezosternum subulatum Thumb. (H.G.Barber det) a small number of adults on garden pea leaves in a small patch on the Vivell farm at Trujillo Alto, Feb. 5 (A.S.Mills).

Agromyza pusilla Mg. adults reared from larvae making serpentine mines in pea leaves—a moderate infestation in a 2-acre planting at Cidra, Feb. 26 (A.S.M.; J. M. Aldrich det.). In Wolcott's "List" but without definite food-plant or locality.

Pepper

Aleurotrachelus trachoides Back (M. D. L. det.) moderately infested a number of plants at the Station at Río Piedras October and was noticed in April. It was also found August 17 to be badly infesting a house plant in Santurce.

Coreocoris batatas Fab. a light infestation on the leaves of a 5 acre pepper field at Vega Alta on Dec. 29 (A. S. M.; H. G. Barber det.)

Myzus persicae Sulz., was found to be lightly infesting the leaves of a 5 acre pepper field at Río Piedras on Feb. 8 (R. F.; P. W. Mason det.).

Disonycha laevigata Jacoby (H. S. Barber det.) lightly infesting the foliage and fruit of peppers and a moderate infestation on cucumber at Loíza on Feb. 7. There were 5 acres of peppers and 1 acre of cucumbers. (A. S. M.)

Chrysocharis parksi Cwfd. adults reared from pupae of *Agromyza pusilla* Mg. mining in pea leaves at Cidra, Feb. 26. 30 per cent of the dipterous pupae parasitized with this or another species. Not in Wolcott's "List."

Saissetia hemisphaerica Targ. (Morrison det.) lightly infesting the stems of 3 plants at the Experimental Farm at Trujillo Alto, Mar. 9 (C. G. A.).

Pigeon Pea

Etiella zinckenella Tr. (Heinrich det.) larvae were found in hampers of pigeon peas from Aguadilla, Lajas and Isabela for shipment to the States (A. G. Harley).

Heliothis virescens Fab. (Heinrich det.) larvae lightly infested hampers of pigeon peas to be shipped to the States from Lajas in March, Aguas Buenas and San Sebastión in January and from Aguadilla and Isabela (A. G. H.)

Icerya purchasi Mask. was found from April on, lightly to moderately infesting pigeon peas grown near infested citrus in Palo Seco and Bayamón.

Saissetia oleae Bern. (Morrison det.) so badly infested 4 bushes at Lajas on Feb. 13 that they were nearly dead (A. G. H.)

PINEAPPLE

Phyllophaga spp. larvae were reported on Apr. 13 by Eugenio Rivera, Agr. Agt. at Manatí, as having badly injured a number of pineapple fields at Vega Baja and Corozal during November and December.

Solenopsis geminatum Fab. also did considerable damage in the same place.

Cutworms (Noctuidae). J. E. Raymer reported (specimens submitted) on Feb. 15 that cutworms had been at that time working for about 3 weeks on 10 acres of his pineapples at Arecibo, causing a loss of about ⅓ of the plants by eating out large holes and destroying any market value of these plants.

Pomarrosa (*Jambos Jambos* L.)

Coccus acuminatus Sign. (Morrison det.) infesting many leaves of a pomarrosa tree at Corozal Feb. 9 (C. G. A.).

Saissetia oleae Bern. (Morrison det.) Infested many leaves of one tree at Corozal, Feb. 9 (A. S. M.)

Colpoptera maculifrons Muir (P. W. Oman det.) adults numerous on the leaves and stems at Bayamón, June 6 (A. S. M.)

Ormenis pygmaea Fab. (P. W. Oman det.) Many adults on the leaves of several trees at Corozal, Apr. 12. (C. G. A.)

Philaenus fuscovarius Stal. one adult on a pomarrosa twig at Bayamón, June 6 (C. G. A.)

Potato, Irish

Xylomyges eridania Cr. (Schaus det.) larvae were found to be eating many of the leaves in a 25 acre field of Irish potatoes on the Ellsworth farm at Cidra, Feb. 5 and a light infestation of the larvae was found on foliage on a 5-acre field of peppers on the Cabrera farm at Loíza on Feb. 8 (A. S. M.)

Cutworms (*Noctuidae*) had destroyed about 5 per cent of one-month old Irish potato plants on ½ acre at Aibonito by Feb. 3 altho many of the injured plants were sending up new shoots; Severo Pagán, Agr. Agt. at Aibonito, reported that 4 or 5 plantings in the vicinity were similarly affected (F. Chardón).

Diabrotica graminea Baly, was reported on Feb. 2 as doing considerable damage to both snap beans and Irish potatoes at Orocovis.

Aleurotrachelus trachoides Buck, badly infested a number of experimental Irish potato plants in the station greenhouses during April.

Nezara viridula L. (H. G. Barber det.). A small number of adults on the leaves of a 25-acre planting of potatoes on the Ellsworth farm at Cidra on Feb. 5 (A. S. M.).

Epitrix cucumeris Harr., the potato flea-beetle, was observed in moderate numbers in several places but not sufficient observations were not made to determine how much damage was done to the various plantings thruout the growing season.

Potato, Sweet

Agromyza ipomeae Frost was present thruout the year as usual in moderate numbers in all patches observed.

Euscepes batatae Waterhouse, was found lightly infesting one tuber in the public market at Puerta de Tierra, San Juan (R. F. & R. G. O.) Specimen sent in for determination on Apr. 6 by F. A. Velasco, Agr. Agent at Guayanilla, as badly infesting a small piece of sweet potatoes.

Spartocera batatae Fab. was abundant in all stages on a small patch of sweet potatoes in Hato Rey the end of April (F. Chardon). It was also reported as fairly abundant in all stages on several plants in Carolina on Nov. 2.

Cylas formicarius Fab. adults were not uncommon during 3 nights of collecting at light at Puerto Real, Vieques Island Sept. 25–27. Arturo Riollano, the local Agricultural Agent, stated that he had observed the insect as generally distributed and very injurious since he had been on the Island from Sept. 1930. It was generally distributed and as injurious as usual in P. R. thruout the year.

Cyrtocapsus caligineus Stal (Miridae, H. G. Barber det.) was found abundant on March 16 on a small patch of sweet potatoes in the Governor's garden in Río Piedras (C. G. A.). Not in Wolcott's "List".

Bemisia inconspicua. What is undoubtedly this whitefly was received from Miguel Díaz, Agr. Agt. at Arecibo under date of Mar. 26 on sweet potato leaves for identification.

Pumpkin

Margaronia hyalinata L. (Schaus det.) was feeding on pumpkin leaves in a small garden at Juncos on Jan. 25 (R. F.).

Rose

Icerga purchasi Mask., the cottony cushion scale, was found moderately infesting a number of large rose-bushes in a home garden in Santurce where Mr. Luciano of the Insular Plant Quarantine Office said it had been present for at least two years; this was the first record for the Island.

Metachroma antennalis Weise, a leaf-beetle, was received under date of Sept. 4 for determination from the Aguirre Sugar Co. The beetles were said to be present in enormous numbers and doing great damage to rose bushes. Out of over 1000 good sized rose bushes over 400 had been killed, the beetles first eating the flowers, next the leaves and finally gnawing off the bark of the woody parts. The beetles first appeared in the spring of 1929 and were present the following year and this, from April into September. It was stated that when disturbed the beetles drop readily. This species was originally described from Puerto Rico in 1885 by J. Weise in "Beitrag zur Chrysomeliden und Coccinelliden Fauna von Puerto Rico" Archiv. fur Naturgeshichte 51(1): 155 and has apparently not been reported outside of the Island. Here it has been reported as rather badly attacking cotton at Quebradillas in June 1922 and was found between leaves and in spider nests on various plants on the beach at Arecibo in May 1923.

Cryptocephalus nigrocinctus Suff. was reported as lightly infesting about 200 rose bushes on the farm of Pedro Osuna in the Barrio of Quebrada Arenas near Río Piedras. The beetles eat the leaves but especially the buds.

Conotelus fuscipennis Er. (E. A. Chapin det.). A moderate number of the beetles on the flowers of 3 bushes at Adjuntas, June 19 (R. G. O.).

Frankliniella insularis Franklin (J. R. Watson det.) reported on June 1 by the local Agr. Agt. in Vieques Id. as doing great damage in 5 different farms and trouble is apparently general; it was the first the growers have noticed trouble in Vieques but stated that it had been previously noted in Mayagüez and other towns but was never reported. Buds attacked never open and flowers are totally spoiled, withered ones being full of thrips when opened especially at base of petals. Some gardens were 100 per cent infested and not a sound rose could be picked. Canna blooms were also attacked but not much damage done.

Silk Oak (*Grevillea robusta* Cunn.)

Asterolecanium pustulans Ckll., was found infesting badly a fair-sized silk oak near Bayamón on Apr. 10; a number of twigs and smaller branches had been killed by the attack.

Spider Lily (*Hymenocallis declinata*)

Xanthopastis timais Cramer (Heinrich det.). From Oct. thru Jan. the larvae were very abundant and doing considerable damage to the leaves on about 10 ornamental plants in a large nursery near Río Piedras on Oct. 10 (M. D. L. & A. S. M.)

Squash (See cucumber and melon)

Sugar Cane

Diatraea saccharalis Fab. was reported in Sept. by I. Flores Lugo, Agr. Agt. of Carolina as causing a large percentage of "dead hearts" on about 4 acres out of about 200 acres of cane in the barrio Cangrejos Arriba of Carolina. The cane had been planted in April or May; this worse affected part had to be plowed up and replanted. The insect was not very abundant on Vieques Island during an inspection trip on March 23 due probably to the unduly high rainfall for the Island (72 ins.) of last year. (M. D. L.) The moth-borer however was worse according to S. C. McCall on the 1931 crop in

Vieques Island than on the 2 previous years' crops under his observation (a total of about 3,500 acres). He stated that Japanese cane, usually supposed to be somewhat less infested than other varieties was however the worst infested of all during this past year.

Pseudococcus boninsis Mask. (= *calceolariae* of authors) was not uncommon on sugar cane in several localities examined in company with C. E. Pemberton on Vieques Island on March 23. (M. D. L.; Pemberton det.)

Pseudococcus sacchari Ckll. was moderately common on both Uba and Crystalina (a little more so on latter apparently) in several sections examined on Vieques Island on an inspection trip on March 23. (M. D. L.)

Aspidiotus sacchari Ckll. was moderately common on a large lot of Uba cane being loaded at the dock on Vieques Island, examined on March 23. (M. D. L.)

Dyscinetus barbatus Fab. adults of a species known to injure cane were absent at lights at Isabela during the whole of July but began appearing again at lights on Sept. 2 at Isabela (G.N.W.)

Ligyrus tumulosus Burm. were abundant at light during July at Isabela and many were being eaten by the imported toad, *Bufo marinus* L. (G. N. W.) An adult was taken at a light in Santurce, Mar. 27 (A. S. M.; E. A. Chapin det.)

Phyllophaga vandinei Smyth. Scattering male adults were collected on Aug. 11 and 12 at Isabela but by the end of the month they were even yet not common there (G. N. W.)

Strataegus quadrifoveatus P. de B. Two adults of the coconut rhinoceros beetle were received under date of July 16 from Alberto Correa from Utuado with the statement that they were found eating the shoots of young cane plants; the injury was noted in several places near Utuado (M. D. L. & F. S.).

Dyscinetus barbatus Fab. Adults of this Scarabeid beetle, an occasional minor enemy of cane were observed in small numbers at lights at Hato Rey on Aug. 31 (M. D. L.). At Isabela adults were not observed at lights thruout August and had not been seen at lights since June 8 (G. N. W.).

Remigia (Mocis) repanda Fab., the sugar cane looper, defoliated a small area of Para or malojillo grass (*Panicum barbinode*), young plant cane and half grown elephant grass (*Panicetum glaucum*) during July at Isabela (G. N. W.)

Sipha flava Forbes, the yellow cane aphis, was observed doing considerable damage in a number of large plantings of young to fairly large cane near both Aguirre and Santa Isabel on Aug. 22. Mr. Foss,

Ass't. Field Manager of the Aguirre Sugar Co. stated on that date that during all of July and Aug. there had been a rather general tho fairly light infestation thruout nearly all of the Company's extensive plantings—this in spite of the fact that the rainfall had been greatly in excess of normal. The insect was present to some extent on Vieques Island on Sept. 27 but S. C. McCall, local Mgr. of the United Porto Rican Sugar Co. on Vieques said it had been absent during the past year as far as he could observe. Its absence or at least scarcity was probably due to much more than normal rainfall on that Island. It was reported on Oct. 7 by Dr. T. Bregger of the Ins. Exp. Station to be fairly abundant on about 2 acres of 3 or 4 months' cane (old ratoons of POJ 2878) on the Station grounds; this in spite of recent abundant rains. He also reported on Oct. 1 that a field of Uba cane, ratooned 4 or 5 months previously, was conspicuously yellow from the road at Jayuya despite much recent rain there also. Under date of Oct. 22, a grower, Enrique López Delgado, wrote that especially in the barrio Miradoro of Cabo Rojo the yellow aphis had by then destroyed almost 25 per cent of the plantings and of the remainder about 50 per cent were infested. He reported the infestation as extending into the other cane growing section of Sabana Grande, San Germán, Lajas, Hormigueros and Mayagüez. In Miradoro not only Japanese cane was attacked but also BH 10(12) and POJ 2878. At the Station a 2 acre planting of 2 months' old ratoons POJ 2878 was lightly infested early in June despite 13 ins. rainfall during the previous month and another planting of the same size and variety was considerably infested thruout all of Feb., Mar. and Apr. with only 6 ins. rainfall for the 3 months.

TAMARIND

Sitophilus linearis Hbst., the tamarind pod-borer, adults and larvae, found feeding in one pod in a crate of tamarinds for shipment to the States, Feb. 25 (C. G. A.; Buchanan det.).

Myelois ceratoniae Zell. (Heinrich det.) 20 per cent of about 100 pods examined at Trujillo Alto found infested with larvae; adults were reared (A. S. M.) Not in Wolcott's "List".

TAMARIX SP.

Saissetia hemispherica Targ. (Morrison det.) fairly abundant on a couple of small trees of Tamarix sp. at the Forestry Station at Río Piedras on Mar. 29 (M. D. L.)

TOBACCO

Practically no definite observations were made on tobacco insects during the year but reports would indicate that the more important insects were present in about the usual numbers. Flea beetles were bad on experimental plantings at the Station during the dry spell thruout Feb. Mar. and April.

TOMATO

Scapteriscus didactylus Latr., was doing considerable damage to young tomato plants in a 3-acre field of tomatoes and to a 3-acre planting of eggplants on Nov. 6 at Loíza; grass land adjoined these fields (A. S. M.).

Myzus persicae Sulz. (P. W. Mason det.) was observed very lightly infesting the foliage of a 3-acre field of tomatoes at Loíza on Nov. 6 (A. S. Mills).

Cyrtopeltis varians Dist. (H. G. Barber det., Miridae) was found lightly infesting the foliage of a 3-acre field of tomatoes at Loíza on Nov. 6 (A. S. M.). Not in Wolcott's "List".

Agallia albidula Uhl. (P. W. Oman det.) lightly infested the leaves of tomatoes at Loíza, Nov. 6 (A. S. M.).

Grasshoppers (*Locustidae*) did considerable injury to several large tomato plants grown for experimental purposes in the greenhouse at the Station during the latter of September. The injury was by the young green nymphs.

Xylomyges eridania Cr. (Schaus det.) larvae moderately infesting tomato fruits, which were being eaten out at the Vivell farm at Río Piedras, Feb. 15 (R. F.)

Atherigona excisa Thom., many larvae in a decayed tomato from Isabela on Jan. 19 (C. C. A.; C. T. Greene).

Empoasca fabalis DeL., moderately infested a 3-acre field of tomatoes on Nov. 6 at Loíza (A. S. M.; P. W. Oman det.).

Flea beetles were bad on tomatoes at the Station in Río Piedras during the dry spell thru Feb., Mar. & Apr.

Epitrix cucumeris Harr. (H. S. Barber det.) was reported in large numbers on a number of plants on a farm at Adjuntas in March (R. G. O.)

Chaectocnema apricaria Suffr. (H. S. Barber det.) in moderate numbers on tomato plants at Jayuya on June 14 (R. G. O.)

Tree Fern

Pseudococcus adonidum L. (Morrison det.) found badly infesting the young fronds of two plants at Mayagüez, Mar. 18 (A.G.H.)

Tropical Almond (*Terminalia catappa* L.)

Ormenis marginata Brunn. (P. W. Oman det.) 3 adults resting on the leaves of one tree examined on Mar. 15 at Río Piedras (A. S. M.) and a small number of adults on the leaves of one coffee bush at the Demonstration Farm at Arecibo on Mar. 8 (C. G. A.)

Megalopyge krugii Dewitz, the puss-moth, was abundant on a number of trees on Apr. 21 near Arecibo (F. S.)

Monobelus fasciatus Fab. Membracidae—a small number of adults on the flower-stalks of several trees at Bayamón on March 21 (R. F.; P. W. Oman det.)

Attelabus sexmaculatus Chev. (L.L.Buchanan det.) One adult on a flower-stalk in examining several "almendro" trees at Bayamón on Mar. 21 (C. G. A.)

Urophorus humeralis Fab. and *Stelidota geminata* Say (Nitudilae, E. A. Chapin det.) feeding in the fruits at Arecibo, Oct. 10 (R. G. O.) and at Añasco, Sept. 29 (A.G.H.) respectively.

Haplothrips gowdeyi Fkln. (J. R. Watson det.) in small numbers on the leaves at Santurce, June 11 (A. S. M.). Apparently the first record for P. R.

Cicadella sirena Stal. (P. W. Oman det.) adults numerous on leaves, Arecibo, May 20 (C. G. A.).

Chalepus sanguinicollis L. (H. S. Barber det.) a small number of adults at base of flower-stalks, Arecibo, May 24 (A. S. M.).

Vanilla

Apodrusus wolcotti Marshall (Curculionidae, L. L. Buchanan det.) A light infestation of adults on flowers and stems found while examining 40 plants at Adjuntas, May 17 (R. G. O.)

Vitex altissima

Saissetia oleae Bern. was fairly abundant on a single small tree at the Forest Service Station at Río Piedras on Mar. 28 (M. D. L.)

Waterlily

Pentalonia nigronervosa Coq., a waterlily aphid, was reported by Dr. N. L. Britton as considerably infesting several plants at San Ger-

mán on Dec. 29 and in March he submitted specimens from the same place (F. Seín det.) In February F. Seín reported several plants killed at Santurce, the leaves being badly infested and curled.

West Indian Laurel (*Ficus nitida* Thumb.)

Gynaikothrips uzeli Zimm. was more or less abundant as usual on nearly all trees examined in various places.

Ischnaspis longirostris Sign. (Morrison det.) was found heavily infesting the leaves of several large trees on the Plaza in Caguas during April.

Ceroplastes floridensis Comstk. (Morrison det.). A light infestation on the leaves of the same trees.

Macrotracheliella laevis Champ. (Anthocoridae, H. G. Barber det.) found feeding in moderate numbers on the thrips mentioned above. Not in Wolcott's "List."

Icerya montserratensis R. & H. common on several of the trees in the Plaza at Caguas but they did not seem to be quite as abundant as last year; this may have been because the observations, such as were made, were during the periods of greater rainfall.

Cattle

Haematobia irritans L. the horn-fly, was observed to be very abundant on all the oxen on the Island of Vieques during a short trip there in September. S. C. McCall, manager of the local Sugar Co. stated that it had been worse this year than usual. One bull was covered with flies and in a greatly weakened condition. It was reported later that this one and several others had died from the effects of the bites. The considerably greater rainfall during some months past could have hardly been responsible for the great increase in numbers of this pest for in Puerto Rico proper it is ordinarily worse on the South Coast where the rainfall is much less than on the North Coast.

For several additional external parasites of animals see the Report of the Veterinarian in Rept. P. R. Agr. Exp. Sta. for 1931.

Man

Culex nigripalpus Theo. (Alan Stone det.) adults collected at light in hotel room in Mayagüez on May 1 (C. G. A.).

Chrysops variegatus Deg. was occasionally annoying at Río Piedras and one or two other localities.

Miscellaneous Records

The following species have presumably not heretofore been recorded from Puerto Rico:

Argyria lacteella Fab. (Pyralidae, Schaus det.) An adult caught at light, Bayamón, Apr. 17 (C. G. A) and another on a lima bean leaf in a field at Loíza, Feb. 7 (A. S. M.).

Psara detritalis Guen. (Pyralidae, Schausdet.). An adult taken on a fruit in a hamper of peppers from Humacao, Feb. 4 (C. G. A.).

Mocis disseverans Wlk. (Noctuidae, Schaus det.). Adults taken at light at Bayamón, Apr. 17 and May 15 (C. G. A.).

Monodes agrotina Guen. (Noctuidae, Schaus det.) at light Bayamón, May 15 (C. G. A.)

Brachymeria ovata Say (Chalcididae, Musebeck det.). An adult reared from a lepidopterous pupa at Mayagüez, June 24 (A. G. H.). It is interesting to note that this species has been recorded from New York State where it has been reared from *Vanessa antiopa* (Cornell Univ. Agr. Exp. Sta. Mem. 101, 1928).

Nasutitermes costalis Holmg. (T. E. Snyder det.) collected at light at Bayamón, June 12 (C. G. A.).

Microbracon hebetor Say (Braconidae, Musebeck det.) in a package of pigeon peas being sent to the States from Ponce, May 18 (R. G. O.)

Chlorion (Ammobia) singularis Smith (Larridae, G. A. Sandhouse det.) collected in the automobile at Guánica No. 13 (A. S. M.).

Colyostichus biannulatus Mayr. (Callimomidae, Musebeck det.) Moderately infesting the fruits of Piper sp. at Cidra, Nov. 13, (R. G. O.).

Calliephialtes n. sp. (Ichneumonidae, R. A. Cushman det.) An adult on a grapefruit leaf at Añasco, May 2 (C. G. A).

Ceratomegilla innotata Muls. (Coccinellidae, E. A. Chapin det.) on a pepper leaf at Vega Alta, Nov. 24 (A. S. M.).

Monanus concinnulus Wlk. (Cucujidae, W. S. Fisher det.) on a window in a dining room, San Juan, Apr. 24 (C. G. A.).

Disonycha spilotrachelus Blake (Chrysomelidae, H. S. Barber det.) adults on an unknown weed, Santurce, June 29 (C.G.A.).

Stephanoderes braziliensis Hopk. (Scolytidae, Blackman det.) 1 adult in a decayed flower-stalk of banana, Bayamón, May 15, (C. G. A.)

Gnathocerus cornutus Fab. (Tenebrionidae, E. A. Chapin det.) An adult on a leaf of watercress in a dining room in San Juan, Feb. 21 (C. G. A).

Cylindera flava Fab. (Cerambycidae, W. S. Fisher det.). An adult on a lima bean blossom, Loíza, Dec. 1 (A.S.M.).

Sapromyza picticormis Coq. (Sapromyzidae, Aldrich det.) adults common on grapefruit at Arecibo, Mar. 1 (R. F.).

Sapromyza slossonae Coq. (Aldrich det.) resting on orange fruit at Pueblo Viejo, Feb. 13 (C. G. A.)

Conoderus bifoveatus Beauv. (Elateridae, W. S. Fisher let.) 2 adults on a flower-bud of *Terminalia catappa* at Barceloneta, May 10 (A. S. M.)

Sitodrepa panacea L. (W. S. Fisher) collected at light in a hotel room, Mayagüez, May 1 (C. G. A.)

Cactylosternum abdominale Fab. (Hydrophilidae, L. L. Buchanan det.). 1 adult at hotel light Mayagüez, May 1 (C.G.A.).

Siphunculina signata Wollaston (Chloropidae, Aldrich det.). An adult on a dining room window in San Juan, Apr. 1 (C.G.A.)

Leucomelina n. sp. (Anthomyidae, Aldrich det.). One adult on trail up El Yunque Mountain, near Luquillo, Mar. 13 (A.S.M.).

Ceropsilopa n. sp. (Ephydridae, Aldrich det.). Adults on under side of grapefruit leaves at Arecibo, Apr. 5 (C.G.A.).

Lasiochilus fusculus Reut. (Anthocoridae, H.G.Barber det.) adults on a decayed flower-stalk of banana at Bayamón, May 15 (C.G.A.).

Exitianus obscurinervis Stal. (Cicadellidae, P.W.Oman det.) 3 adults on leaves of an unidentified weed at Arecibo, June 7 (C.G.A.).

Megoura n. sp. (Aphididae, P.W.Mason det.). A moderate infestation on 5 plants (plant unrecorded) examined in Santurce, June 20 (A.S.M.).

Pycnoderes heidemanni Reut. and *Polymerus cuneatus* Dist. (H.G. Barber det.) collected by sweeping weeds in Santurce, June 29 (C.G.A.).

Coreocoris batatas Fab. (Coreidae) and *Engytatus geniculatus* Reut. (Miridae, H.G.Barber det.) 1 adult each at Añasco, May 2 (C.G.A.).

Oncopeltus fasciatus Dall. (Lygaeidae, H.G.Barber det.). 1 adult on a flower at Arecibo, Apr. 22 (C.G.A.).

Anasa scorbutica Fab. (H.G. Barber det.) a squash bug, was observed lightly infesting a 2-acre planting of squash at Vega Alta, Nov. 24 (A.S.M.).

The following records, altho not entirely new to Puerto Rico, are those of insects known heretofore only from the type material from Puerto Rico or for the most part from only one or two previous records:

Xestocephalus maculatus Osb. (Cicadellidae, P.W.Oman det.) collected at light in a hotel in Mayagüez (C.G.A.). Known only from types taken on Inga sp. on the Cayey road at about 2,000 ft. elevation.

Cicadella coffeeaphila Dozier (P.W.Oman det.). Several adults on an unidentified plant on the trail up El Yunque Mountain (A.S.M.).

Agallia pepino DeL. & Wolc. (Cicadellidae, P. W. Oman det.) collected at light in Mayagüez, May 1 (C.G.A.). First record from the West end of the Island.

Thamnotettix colonus Uhl. (Cicadellidae, P.W.Oman det.) collected at light in Mayagüez, May 1 (C.G.A.). Recorded by Osborn from several localities but not from the coast at the west end of the Island.

Deltocephalus nigripennis DeL. (Cicadellidae, P.W.Oman det.) at light in Mayagüez, May 1 (C.G.A.). Known only from type male from Boquerón.

Protalebra lenticula Osb. (Cicadellidae, P.W.Oman det.) 2 adults at light, Bayamón, May 17 (C.G.A.). Known only from type material from Coamo, Jan. 1929.

Psyllia minuticona Cwfd. (Psyllidae, P.W.Oman det.) at light, Bayamón, May 15 (C.G.A.). Only previous records is "common on *Inga vera* at Lares 1922 and thruout the coffee districts. (Wolcott's "List" p. 274).

Colpoptera brunnea Muir (Fulgoridae, P.W.Oman det.) at light, Mayagüez, May 1 (C.G.A.). Osborn says probably one of the forms listed by Wolcott under Carda sp. from several other localities; types from Utuado, Toa Alta and Ciales.

Acinopterus angulatus Laws. (P.W.Oman det.). Caught by sweeping weeds, Santurce, June 29 (C.G.A.). Only record for the North Coast.

Euryopthalmus obovatus Barber (Pyrrhocoridae, H.G.Barber det.) common as adults on branches and trunk of three orange trees at Peñuelas, Jan. 26 (R.G.O.). Apparently known from P. R. only by a female paratype.

Zelus longipes L. (Reduviidae, H.G.Barber det.). An adult resting on a guava leaf at Trujillo Alto, Oct. 23 (A.S.M.). Previously recorded from Trujillo Alto in 1912; elsewhere only in the mountains.

Icerya montserratensis R. & H. reported by Wm. Barbour, Chief Insular Forester, as found moderately infesting on May 4 a small

unknown native tree on the north slope of the Luquillo Mountains about 5 miles south of Luquillo at about 750 feet altitude.

Haptonchus luteolus Er. (Nitidulidae, E.A.Chapin det.) 3 adults in a decayed star apple fruit, Arecibo, Apr. 22 (C.G.A.). Little known in P. R.

Lobiopa insularis Cast. (Nitidulidae, E.A.Chapin det.) A great many adults on the bark of a tree of *Petitia dominguensis* at Arecibo, Jan. 26 (C.G.A.) Little known in P. R.

Chysobothris megacephala C. & G. (Buprestidae, M.D.L. det.) An adult flew into the car of Raphael Rodríguez of the College of Agriculture while passing thru Isabela, May 18. In Wolcott's "List" as collected in 1922 but "date and locality unknown".

Xyleborous affinis Eichhoff (Scolytidae, M.W.Blackman det.) An adult at light in a hotel, Mayagüez, May 1 (C.G.A.) Listed from P. R. previously only by Leng & Mutchler.

Platypus rugulosus Chapuis. (Scolytidae, M.W.Blackman det.) 2 adults at light in a hotel in Mayagüez, Apr. 30 (C.G.A.). Only previous record is at light at Mameyes in 1913.

Lema dorsalis L. (Chrysomelidae, H.S.Barber det.) Adults numerous on the leaves and flowers of an unkonwn weed at Arecibo, May 24 (C.G.A.). Previously listed from Aibonito, Coamo, Boquerón and Caguas.

Disonycha laevigata Jacoby (Chrysomilidae, A.J.Mutchler det.) Often very injurious to beets, swiss chard, etc., was reported by S. Molinary, Agr. Agt. at Carolina as very abundant on the common weed "Jamón con huevo" (*Achyranthes Bettzickiana*) at Loíza during October; many adults were submitted for determination. Apparently a new food-plant for P. R.

Panagaeus quadrisignatus Chev. (Carabidae, L.L.Buchanan det.) Adults at light in Bayamón, Apr. 17 (C.G.A.). Previously listed only from Aibonito and Guánica.

Callopisma borencona L. & M. (Lampyridae, H.S.Barber det.). An adult on a pomarrosa leaf at Bayamón, Mar. 21 (R.F.). Not many locality records.

Callopisma emarginata L. & M. (Lampyridae, H.S.Barber det.). A small number of adults on orange fruits at Peñuelas, Jan. 26 (R.G.O.). Previously listed only from type material from: Mayagüez, Adjuntas, Río Blanco Valley and Utuado.

Psyllobora nana Muls. (Coccinellidae, E.A.Chapin det.). Two adults on a cashew nut leaf, Santurce, April 6 (A.S.M.). Little known in P. R.

Callosobruchus chinensis L. (Bruchidae, H.S.Barber det.). An adult on a pepper fruit in a crate from Isabela, Apr. 4 (C.G.A.). Apparently not often recorded in P. R. (See also under bean).

Eurema euterpe Mén. (Pieridae, Schaus det.). A small number of adults at Cidra, Feb. 26 (A.S.M.). Apparently little known in P. R. but easily confused with *E. portoricensis* according to Dr. Forbes.

Atrytone vitellius Fab. (Hesperiidae, Schaus det.). Caught in a net at Río Piedras, June 22 (C.G.A.). Apparently not recorded since 1922 but probably common in various localities. The larva is known as a minor pest of sugar cane.

Calisto nubila Lathy (Satyridae, Schaus det.). 3 adults caught on the trail up El Yunque mountain, back of Luquillo Mar. 13 (A.S.M.). Apparently only a few previous records but according to Dr. Forbes undoubtedly common and widely distributed.

Dichomeris manellus Mösch. (Gelechiidae, as *Dichomeris*, Busck det.). An adult on a pomarrosa leaf at Barceloneta, Mar. 22 (A. S.M.). Apparently known heretofore from P. R. only from type material, without definite locality. Forbes, following Meyrick lists this as a *Trichotaphe* (Sci. Surv. P. R. 12:121, 1930).

Lymire flavicollis Dewitz (Syntomidae, Schaus det.). An adult reared from a pupa on a cucumber leaf at Caguas, Jan. 25 (R.F.). Previously recorded only from Naguabo, Coamo, Lares (Seín) and Palmas Abajas, back of Guayama (Hoffman).

Pseudosphinx tetrio L. (Sphingidae, Heinrich det.). One larva from Mona Id. (A.S.M.) which is apparently the first record for that place.

Epistor lugubris Drury (Sphingidae, Schaus det.). Adult at light in Santurce in December (A.S.M.). Recorded only from Río Piedras and Lares.

Syngrapha egena Guen. (Noctuidae, Schaus det.). An adult on a lima bean leaf, at Cidra, Feb. 5 (A.S.M.). Only previous published record is from Cayey but specimens are in the Ins. Exp. Sta. coll. also from Comerío.

Melipotis januaris Guen. (Noctuidae, Schaus det.) An adult at light in San Juan, June 23 (C.G.A.). Apparently but little known in P. R.

Leucinodes elegantalis Guen. (Pyralidae, Schaus det.). Adult at light in Bayamón, May 15 (C.G.A.). Previously only recorded from P. R. without definite locality or date but specimens are in the Cornell Univ. coll. (Forbes det.) from 7 different widely separated localities by various collectors.

Lipocosma hebescalis Mösch. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from the type but Dr. Forbes collected several specimens in 1930.

Cataclysta miralis Mösch. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from the type material, without definite date or locality but Dr. Forbes found it common on El Yunque and also collected it at several other localities in 1930.

Crambus fissiradiellus Wlk. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from P. R. without definite date or locality.

Crambus ligonellus Zell. (Pyralidae, Schaus det.). An adult at light in Bayamón, Apr. 17 (C.G.A.). Previously recorded only from "P.R." but Dr. Forbes collected a number of specimens in 1930.

Samia ecclesialis Guen. (Pyralidae, Schaus det.). 2 adults at light in San Juan, Apr. 24 (C.G.A.). Previously recorded from "P.R." but according to Dr. Forbes this is abundant and general and there are many specimens in the Cornell University collection.

Lamprosema ebulialis Guen. (Pyralidae, Schaus det.). An adult at light in Santurce, Dec. 4 (A.S.M.). Not previously recorded from P. R. but there are specimens in the Cornell Univ. coll. from El Yunque (Forbes, 1930) and Lares (Seín, 1930 or 1931).

Hunterellus hookeri Haw. (Encyrtidae, Mueseback det.), found on a window in a dining room in San Juan, Apr. 2 (C.G.A.). Only 2 previous records from P. R.

Christolimorpha plesius Vier. (Ichneumonidae, R.A.Cushman det.). An adult on a leaf of Psidium sp. at Mayagüez, June 12 (A.G.H.). Only previously known from type.

Notogonidea vinulenta Cress. (Sphecidae, S.A.Rohwer det.). Adults numerous on the blossoms of many grapefruit trees at Barceloneta, May 10 (C.G.A.). Only 1 previous record—from Mayagüez (Van Zwaluwenburg's typewritten "List" of 1914).

Polistes crinitus var. *americanus* (Vespidae, G.A.Sandhouse det.). Adults numerous on the blossom of many grapefruit trees at Barceloneta, May 10 (C.G.A.). Apparently not before recorded from the north coast.

Polistes major Beau. and *Sceliphron coementarium* Drury (F. Seín det.). Sent in from Bayamón by F. Joglar Rodríguez from a grapefruit tree, Aug. 6. Both of these species were apparently unknown in the Island until this past year.

Exomalopsis globosa Fab. (Anthophoridae, G.A.Sandhouse det.). 1 adult in an automobile at Arecibo, Apr. 22 (C.G.A.). Previously

known in P. R. from only one record "tunneling in hard clay at Guánica (G.B.Merrill)."

Cycloptilum antillarum Redt. (Gryllidae, A. N. Caudell det.). A small number of nymphs on the leaves of a maga tree, *Montezuma speciosissima,* at Arecibo. May 24 (A.S.M.) an adult found in a house in Santurce, Oct. 20 (A.S.M.). Apparently little known in P. R.

Neorandania chalybaea Wied. (Stratiomidae, C.T.Greene det.). Many adults resting on grapefruits at Arecibo, Apr. 5 (R.F.). Little known in P. R.

Tabanus hookeri Knab. (A.S.M., Alan Stone det.). One adult, at light at Santurce, Feb. Not in Wolcott's "List" but recorded from Vieques Id., P. R. in Curran's First Suppl. to Diptera of Porto Rico. Described from Porto Rico (Ins. Insc. Men. 3(4) : 48, 1919).

Volucella pallens Wied. (C.T.Greene det.). An adult resting on a *Termalia catappa* leaf, Arecibo, July 27 (M.Kisliuk) and an adult on an orange at Peñuelas, Feb. 25 (R.G.O.). Little known in P. R.

Chrysotus excavatus VanD. (Dolichopodidae, Aldrich det.). Adults on grapefruit in small numbers at Arecibo, Mar. 1 (C.G.A.). Previously recorded only from Aibonito.

Psilopus diffusus Wied. (Dolichopodidae, C.T.Greene det.) Adults resting on fruits in small numbers on several sour orange trees, Arecibo, Feb. 23 (C.G.A.). In Wolcott's "List" but without definite locality.

Proctacantha rufiventris Macq. (Asilidae, C.T.Greene det.). 1 fly resting on a tropical almond leaf, Arecibo, July 27 (Max Kisluik). Stated by Wolcott to be "quite common" but only actually recorded from 2 or 3 definite localities.

Sigaloessa bicolor Lw. (Oscinidae, Aldrich det.). A moderate number of adults resting on leaves of several banana plants at Bayamón, Apr. 8 (C.G.A.). Recorded only from Coquillett's original record published in 1900.

Gonia crassicornis Fab. (Tachinidae, Aldrich det.) was reared from a cocoon of the Noctuid *Xylomyges eridania* Cr. Previously recorded by Jones and Wolcott (Jour. Dept. Agr. P. R. 6(1) : 47, 1922) as a parasite of *Laphygma frugiperda* S. & A.

Archytas antillicola Curran. (Tachinidae, Aldrich det.). One adult on trail up El Yunque mountain, Mar. 13 (A.S.M.). Known only from the types (1927) altho these were from several localities, mostly at the higher elevations also.

Drosophila repleta Woll. (Aldrich det.) Adults on window in dining room in San Juan, Apr. 1 (C.G.A.). Previously recorded only from 2 specimens, Santurce 1914.

THE RELATION OF ANTHER COLOR AND THE PROPORTIONS OF STARCH FILLED POLLEN GRAINS IN THE SUGAR CANE

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The arrowing or flowering of most commercial sugar cane varieties in Puerto Rico takes place from the last week in October to the middle of January. The most effective period for crossing work extends from the middle of November to mid-December. Previous to this period the numbers of arrows are limited and after this period the condition of the arrows is not so good. Emergence from the sheath or boot is slower, in many instances incomplete, irregular, and slower.

Within the limits of the material available it is desirable to obtain as many new combinations and as large a number of crosses within the combinations as possible. Where trained help is scarce it is desirable to have some rapid method of determining pollen fertility of the varieties to serve as males. Bannier (1) describes a suitable method but it requires more personnel than the writer has had available in carrying out his work at Río Piedras, P. R. During the years 1929 and 1930 the arrows and attached canes were cut in the late afternoon, brought to the laboratory, and placed in quart Mason jars with water and a quantity of 6 per cent H_2SO_3 sufficient to approximate a 1 : 3000 solution. The following morning when pollen shedding took place, samples were collected on slides and examined microscopically in a saturated solution of iodine in chloral hydrate. Counts of iodine positive and iodine negative staining pollen grains were recorded. Anther color was noted under field conditions. In 1931 with a larger number of unknown potential males coming into bloom it was realized that our methods would not permit us to do much more than make pollen observations if the methods were not changed. Hence the arrows were cut without the attached canes. Small samples were examined microscopically from florets unopened but just below those which shed pollen for that day. The arrows were then placed in sheets of newspapers between blotters and dried for 10 days to two weeks. Blotters were changed every 2–5 days. Further samples were taken at a later date and comprise the data presented in table II.

Pollen counts

In crossing campaigns previous to 1930 it was noted that varieties with purple or purplish anthers seemed to give larger counts of iodine positive grains than those with yellow. In order to observe any relation between degree of color of anther and iodine reaction a number of varieties were examined. They were grouped into three classes with respect to color of anthers. In 1930 pollen counts were made of 15 varieties. All arrows were taken from field plantings unless otherwise noted.

TABLE I

RELATION OF ANTHER COLOR AND IODINE REACTION 1930

Variety	No. of pollen grains counted	Per cent Iodine Positive in		
		Purple Anthers	Med. Pur- Anthers	Yellow Anthers
P.R. 358	1069		37.04	
Co-281	1487		54.67	
SC 12-4 (Drums)	1439		57.19	
SC12-4	1335	89.97		
POJ-2878	1399		82.13	
P. R.-492	205		56.10	
POJ-2725 (Collection)	1110			3.93
POJ-2725	No count			Less than 1
Kassoer	740	51.61		
Tuc-472	1349	72.45		
POJ-2364	869			1.62
Badilla	555		49.91	
POJ-36	No count			Less than 1
D-1135	1204	66.03		
Tuc-450	613	66.07		
Tuc-454	513		51.85	
T-2009	1028		77.62	
Average		71.74	60.25	2.91
Maximum		89.97	83.13	3.93
Minimum		51.61	37.04	1.62

The assistance of Miss Ana Molina, Inst. in Biology, U. P. R., in making most of the counts in table I is hereby acknowledged.

In general the data seem to show that intensity of purple coloration of the anthers is some indication of the fertility of the enclosed pollen grains. Undoubtedly as between yellow and purple of medium or better, the latter are to be preferred for use as males. It is interesting to note that in the case of SC 12-4, pollen from field grown plants had a higher percentage of iodine positive pollen grains and more intense purple color than those grown in drums.

In 1931 notes were available on 41 varieties and they were grouped according to anther coloration into 4 classes. The data presented in table II are based on the sum of the counts of the first and second samples as mentioned above. There is essentially no difference between the counts made in November 1931 and those made in August

1932. The correlation coefficient between the two series of observations was 0.642 ± .059. See table II.

TABLE II

RELATION OF FRESH AND DRY FLOWERS

Percent Positive November 1931	Percent Positive August 1932									
	0–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	
0–10	14	1	1	....	1	....	....	....	....	17
11–20	1	....	....	1	....	....	....	....	....	2
21–30	....	....	3	2	1	....	....	....	....	6
31–40	1	....	....	1	1	....	....	....	....	3
41–50	....	....	....	1	2	....	1		....	4
51–60	....	....	....	....	3	3	....	....	....	6
61–70	....	....	....	....	1	....	....	1	1	3
71–80	....	1	1	....	....	....	....	....	....	2
	....	....	....	....	....	1	....	1	....	2
	16	2	5	5	9	4	1	2	1	45

NOTE: The discrepancy in total observations between tables II and III is due to the fact that anther color determinations were lacking in 4 cases.

TABLE III

RELATION OF ANTHER COLOR AND IODINE REACTION 1931

Purple Anthers			Med. Purple Anthers			Tinged and Light Purple Anthers			Yellow Anthers		
Variety	No. Pollen grains	Per cent Iodine Positive	Variety	No. Pollen grains	Per cent Iodine Positive	Variety	No. Pollen grains	Per cent Iodine Positive	Variety	No. Pollen grains	Per cent Iodine Positive
PR 26-14	930	69.9	POJ-2878	718	27.0	PR-334	500	47.0	POJ-36	750	0.0
PP-26-8	772	59.3	Al-32	506	30.2	PR-358	474	34.8	G-119	750	0.0
			PR-507	649	55.5	PR-422	849	56.5	POJ-2883	700	0.0
			US-875	577	52.4	PR-202	705	35.2	PR-728	435	24.2
			PR-702	732	50.0	Al-15	1408	0.59	Tuc-521	425	2.8
			Co-281	859	37.0	Tuc-450	556	5.8	POJ-2364	750	0.0
			PR-701	717	74.9	PR-547	1180	47.2	Tuc-491	500	0.0
			PR-208	421	74.6	Tuc-472	1294	11.2	POJ-2725	500	0.0
			PR-207	638	70.9	Tuc-454	1016	0.17	CP-807	850	0.0
			PR-357	547	32.0	PR-720	725	54 0	PR-440	763	11.7
			PR-26-187	735	45.0	Co-213	576	26 4	POJ-36M	700	0.0
			PR-338	613	44.0	POJ-2822	879	35.0	CH-64-21	700	0.0
						Ba-11569	1026	8 0	Merthi	700	0.0
									PR-807	700	0.0
Total	1702	65.1		7712	48.9		11188	27.7		9223	2.25
Maximum		69.9			74.9			56.5			24.2
Minimum		59.3			27.0			0 17			0.0

The 1931 data show a similar trend of the average per cent of positive reacting pollen grains to increase with the increase in intensity of the anther color. The range and therefore the variability is very high in both years.

If we may assume that arrows with 50 per cent fertility as indicated by the iodine test are worth using as parents then anything below medium in color should be only used after a microscopical examination with iodine has been made. Of course all varieties used as males should be checked up for pollen fertility by the iodine test sooner or later.

SUMMARY

1. It has been shown that within rather wide limits there is a positive relationship between pollen fertility as indicated by the iodine test and the degree of anther coloration in the sugar cane.

2. That pollen samples taken from dried flowers nine months after the fresh samples have been taken are similar in their iodine reaction has also been demonstrated.

REFERENCES

(1) Bannier, J. P. De Rietveredeling aan het suiker proefstation te Pasoeroean; Techniek, richting en resultaten van 1893–1925. Archief v. Suikerind. Ned. Indie, Meded. Proefstation Java suikerindustrie. Jaargang 1926 No. 19.

BACTERIAL WILT OF TOBACCO IN PUERTO RICO AND ITS INTERTRANSMISSION TO OTHER SOLANACEOUS HOSTS

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Although bacterial wilt of the Solanaceae has been repeatedly reported by various investigators from Puerto Rico, Henricksen (**2**), Stevenson (**9**), Stevenson and Rose (**8**), Smith (**7**), Thomas (**11**), López (**4**), Seaver and Chardon (**6**), Cook (**1**), and more recently by Nolla (**5**), attacking tomato, eggplant, pepper, potato and other plants*, the disease has never been found naturally in tobacco nor has been produced artificially by inoculation with supposedly pure cultures of *B. solanacearum* E. F. S. from other hosts. Cook (l.c.) suspected the pathogene to be a different one when his cross inoculations with the organism from eggplant succeeded on tomatoes and peppers but failed on tobacco. Nolla (l.c.) in a very comprehensive study of the disease concluded that the Puerto Rico organism, although morphologically similar to *B. solanacearum* E. F. S. was a strain incapable of infecting tobacco. He suggested, however, the possibility of all varieties of tobacco on the island being resistant to the organism.

The present investigation was initiated with the purpose of ascertaining why tobacco was not attacked by the Puerto Rican strain and, if so, the relationship between the tobacco organism and the one attacking other Solanaceous hosts of economic importance, viz., tomato, eggplant, pepper and potato. With the introduction of new tobacco varieties as a means of improving our standard types and, more recently, with the expansion of the vegetable growing industry into what was formerly tobacco land, the importance of elucidating this point not only has a purely scientific value but also a decided economic importance.

HISTORY

The writer found what was apparently the first observed case of bacterial wilt on tobacco in Puerto Rico in the summer of 1931, among two of our standard varieties, Ceniza and Utuado, growing in a field that for the last 10 years has been planted with sugar cane and, more recently, with strawberries. The plants were about 18

* Zinias (*Crassina elegans* (Jacq.) Kuntze); *Solanum torvum* L.; *Solanum caribaeum* Dunal. Undoubtedly many other plants are attacked under our conditions.

inches high and growing rapidly. Two of the Utuado plants were carefully pulled and their root systems washed. No symptoms of fungus attack was evident and the roots, except for the end of the main branch, appeared to be healthy. After stripping the plants of their leaves, the greater part of the stem was cut off until almost a solid core of woody tissue near the base of the stalk was left. The roots were then set in a beaker with distilled water in such a way as to leave the stub above the surface. In a few minutes, a slimy, brownish exudation appeared on the cut surfaces. A microscopic examination of the exudate, revealed the presence of enormous numbers of motile, rod shape organisms, similar in morphology to *B. solanacearum* E. F. S.

Agar plates from sterile water suspensions of the ooze failed to develop colonies after five days, but streaks made directly from the exudate made good growth. From these slants, agar plates were poured which in 48 hours developed watery, translucent colonies. Sub-cultures were then made from these colonies and in eight days developed the typical brown pigment characteristic of this organism.

MORPHOLOGIC SYMPTOMS.

In the Field.—The symptoms of the disease when occurring naturally in the field are typical and distinct. The first indication is the sudden wilting of one or more of the youngest leaves. When only one leaf wilts it is usually the third or fourth youngest from the top. The leaves wilt either totally or partially; when partially, the tip or only the area of the blade at either side of the midrib withers; when the whole leaf wilts, it droops, so that only the ventral side of the leaf is visible. The wilting and drooping of a single leaf near the top is an unmistakable early symptom of the disease. These early manifestations of infection are usually evident late in the morning hours when a bright day follows previous heavy rains.

If the variety is resistant to the malady, the symptoms progress no further and in a week or two the plant completely recovers. Because of the fact that all of our standard varieties are highly resistant to infection, as will be demostrated further on, this may explain the reason why the disease has been previously overlooked.

In case of susceptible varieties, successive wilting of the other leaves follows, usually the older ones, and the normal growth of the plant is checked so that adjacent healthy plants shortly outgrow them. Wilting is not uniform along the plant, but usually one side is more wilted than the other or not wilted at all. Wilted areas may show a slight yellowish discoloration, but a marked chlorosis is not

typical. The leaves finally rot, in some cases, only the stalk with a few stripped midribs remaining. If hot dry weather follows the initial symptoms, the leaves are irregularly scalded, in a short time dry up, become brittle and desintegrate. With moist weather, the leaves gradually turn yellow, then brown and finally rot without becoming brittle. In advanced stages, the stem blackens, becomes hollow and shrivels up.

When the roots of diseased plants are examined dark grayish to black, slightly sunken blotches are often present in the main branches. Usually the rootlets arising from these branches are dead and their cortex is easily removed. When cross sections of the affected roots are made, droplets of a slimy ooze appear on the cut surfaces. For diagnostic purposes this is the critical evidence of infection by bacterial wilt.

Under Puerto Rican conditions, the writer had no difficulty in differentiating between fungus wilt as produced by *Rhizoctonia solani* Kühn, *Phytophthora parasitica* var. *nicotianae* Tucker, and bacterial wilt, as soon as the early symptoms of both types of infection are evident. In the former cases, the wilting is sudden and general, that is, practically all the leaves wither and droop simultaneously and a marked chlorosis is immediately noticeable. Wilted plants do not recover from day to day with the advent of moist weather and cloudy mornings as plants attacked by bacterial wilt do in the early stages. So clear cut is the difference that the writer never failed to obtain critical signs of bacterial wilt on plants marked as such as soon as the first symptoms were observed.

Symptoms were observed at all stages of growth from three weeks after setting plants in field.

On Inoculated Plants.—The symptoms manifested by inoculated plants in pots were identical in every respect to those observed under field conditions, especially so, in the early stages. Inoculated plants, however, seldom were completely destroyed; partial or complete recovery being oftener the case. In many instances, recovered plants would exudate the slimy ooze even when cut 10 inches above the point of inoculation.

Brown and sunken longitudinal streaks along the stem were often produced by inoculated plants, but this symptom was never observed in the field. When these areas are punctured, exudation of ooze follows.

Dwarfing and undeveloped root systems are also pronounced symptoms of inoculated plants.

HISTOLOGIC SYMPTOMS

Bacterial wilt is primarily a disease of the vascular tissues of the plant. In tobacco as well as in other suscepts studied, however, the pith is nearly always affected and in many cases also the cortex.

Tranverse sections of affected parts of the roots or stems shows the vessels completely occluded with the bacterium. There is a pronounced discoloration of the wood which varies in color from reddish brown to dark brown. Shortly after the cut surfaces are exposed a sticky exudate oozes out of the vessels in tiny droplets which rapidly enlarge and coalesce. Both the consistency and the color of this ooze varies with individual cases, in some instances being watery while in other it is very thick. The color varies from pearl white in plants recently infected to a very dark brown in advanced cases, although individual droplets from the same stem may differ among themselves as to color.

The pith is nearly always affected and when the attack is severe it is rapidly disorganized. As a result the stem collapses, forming indentations and twisting around. It is also stained brown, but to a lesser degree than the woody tissues. In some cases the bacterium invades the cortex forming necrotic areas which enlarge with the advance of the infection. The woody tissues, although becoming functionless, are not disorganized until invaded by secondary saprophytes.

ETIOLOGY.

Morphological, cultural and pathogenecity studies establishes the organism responsible for bacterial wilt of tobacco in Puerto Rico as identical to *Bacterium solanacearum* E. F. S. (*Phytomonas solanacearum* (E. F. S.) Com. S. A. B.)

The pathogene is extensively disseminated throughout the island and is responsible for a similar disease in other Solanaceous hosts among which tomato, eggplant, pepper, and potato are the most important.

MORPHOLOGICAL AND CULTURAL CHARACTERISTICS.

The following characteristics are typical for the organism under discussion:

Rods, 0.5 μ in width, varying in length from 1.0 μ to 1.5 μ; motile by a single polar flagelum (two preparations stained by Cesares—Gil method) which is 3 or 4 times longer than the cell; motility is best observed in hanging drops of fresh ooze or in broth cultures 48 hours old at room temperature (25° C. to 30° C.). The cells stain well

with ordinary anilin dyes but specially so with carbol fuchsin. In good preparations a more pronounced staining of the polar regions as well as a plain constriction at the center are evident.

Standard nutrient agar plates begin to show surface colonies in from one to two days; in general these are small, circular and slightly raised, transparent at first, resembling tiny drops of water on the surface of the agar, changing to whitish when seen by reflected light in one to two days, but brownish by transmitted light and producing a brown pigmentation which varies in intensity from very light to dark brown after a week old, and diffuses into the agar. Sub-surface colonies are variously shaped, usually elliptical.

Nutrient agar and litmus lactose agar slants show a filiform type of growth; the agar in the latter case acquiring a more intense blue color with age particularly near the region of growth. The streaks are semi-liquid during the first few days and run into the condensation water if kept upright.

Gelatin stabs show no liquifaction when two weeks old.

Milk is cleared without precipitation of the casein and the medium acquires a bright brownish hue. Litmus milk becomes more intense blue with age without precipitating.

Broth cultures become clouded in 24 hours when a recently isolated culture is used; old cultures require a longer time for clouding the medium. In a few days a white precipitate is deposited at the bottom of the tube and the liquid becomes intensely clouded, with or without the formation of a very slight pelicle. As the cultures become old, the supernatant liquid becomes clear and develops a color which varies from amber to dark brown.

Growth on potato slants is at first watery, spreading, whitish or yellowish in color, later turning brown and the water becoming heavily clouded.

On Dunham's solution growth is similar to that of broth cultures. No growth has been observed on Cohn's solution.

No gas or acid is produced from saccharose, dextrose, glucose, maltose, lactose or mannit broths.

Nitrates are not reduced; indole is not produced.

Spores have not been observed. The organism is aerobic and gram negative.

The length of time for which the organism remains viable in pure cultures is variable; good growth has been obtained from broth cultures three months old. Liquid cultures remain viable for a longer period than cultures on solid media.

The above description of cultural and morphological characters corresponds to the ones given by Smith (l.c.), Stanford and Wolf (**10**), Nolla (l.c.) and other investigators elsewhere for *B. solanacearum* E. F. S.

INOCULATIONS.

Methods and Inoculum.—The irregular behavior of plants inoculated with *B. solanacearum* E. F. S., was first noted by Smith (l.c.) and confirmed by practically all investigators on the subject since then. Similar difficulties were encountered by the writer. These were augmented by the fact that the organism rapidly or immediately loses its pathogenic ability when artificially cultured.

In an effort to obviate these difficulties, several methods were tried in the early stages of these studies, two of which were finally adopted in conducting inoculations and cross-inoculations with marked success.

Both the aerial and the underground parts of the suscepts were inoculated. Except in two or three instances, all inoculations performed above ground failed. They even failed when conditions for the development of the organism at the point of inoculation were provided. Identical inoculum, when used simultaneously underground, on plants grown alike, would reproduce the symptoms of the disease.

Sub-cultures from poured plates; broth cultures made directly from ooze or from sub-cultures; streaks made directly from ooze; colonies from poured plates; sub-cultures on potato slants; ooze directly from diseased plants, and pieces of diseased wood were used as sources of inoculum. Except when ooze or pieces of wood were used, the age of each of the various cultures employed varied in from 1 to 7 days. Pieces of wood were invariably used the same day and ooze was used when not more than 48 hours old.

Of these, agar streaks made directly from ooze, pieces of wood and pure ooze were the most successful sources of inoculum; the last two mentioned giving very consistent results. Nolla (l.c.), pointed out that inoculations with ooze scarcely ever failed.

Symptoms produced by sub-culture inoculations no matter on which medium grown were usually of a localized nature; there is a slight brownish discoloration following the vascular bundles for a short distance below and above the point of inoculation or the pith was sometimes affected. Critical symptoms, however, were rarely, if ever, obtained.

In performing most of the inoculations upon which the conclusions arrived at in this paper are based, the usual procedure was to inoculate young, rapidly growing plants in 8-inch pots in sterilized soil, about one inch below the surface of the ground, either with ooze or with pieces of diseased wood from the same or other suscepts studied. The necessary ooze was obtained from roots and stems of recently wilted plants in the field. The soil around the stem near the surface of the ground was carefully removed and the stem washed with distilled water at the desired place. A slight injury with the end of a sharp scapel so as to pierce the woody cylinder was made and the ooze inserted at that point. The soil was then replaced and the plants watered once or twice a day until discarded. Checks were similarly treated, except that no inoculum was provided.

When pieces of diseased wood were used, thin slices of the material were cut with a sterile razor in such a way that one side of the section was thicker than the other, and kept in sterile water until used. With a sharp scapel, a longitudinal cut was made after proceeding as above. The end of the scapel was not removed until, with a pair of tweezers, the slip of wood, thinner edge first, was inserted into the cut. The whole scheme is in the nature of an underground graft.

These two methods were equally successful, but because of the large amount of ooze required when making extensive inoculations, the latter was much more convenient.

Pathogenicity.—Tobacco plants inoculated as above from naturally wilted plants developed typical wilt symptoms in from 4 to 10 days. When resistant varieties were used recovery slowly followed these early symptoms; when susceptible varieties were inoculated, the symptoms usually terminated in the death of the plants.

Broth cultures of the inoculum were plated when two days old and sub-cultures made. Soon after the symptoms on inoculated plants were well defined, the plants were pulled, washed and examined for the critical sign of infection: exudation of ooze for some distance above or below the point of inoculation. Sub-cultures of this ooze made as above were then compared with the original ones. In every case, they were found to be morphologically and physiologically identical.

Agar plates from broth cultures of the ooze nearly always yielded a single type of colony with slight or no contaminations. This is particularly the case when fresh ooze from recently wilted plants is collected as far up in the stem as possible. Parallel inoculations with these typical colonies with few exceptions failed, while those made

with ooze were successful. This points to the rapidity with which the organism losses its infective powers. Sometimes abundant fungus contaminations (*Fusarium* sp. and *Actinomyces* sp.) would appear in the plates. In these cases, the results obtained from ooze or wood inoculations were not considered.

In all inoculation work done, an average of two checks for every 10 plants treated were carried. They always failed to show the disease.

Intertransmission.

Nolla (l.c.) has shown that *B. solanacearum* E. F. S., as occurs in Puerto Rico, is intertransmissible to tomato, eggplant, pepper and potato. In an effort to establish the pathogenic relationship between the tobacco organism and these hosts, over 500 inoculations were made, more than one-half of which were successful. The routine procedure was to determine first the pathogenicity of the ooze from each suscept on itself and then to make direct and reciprocal inoculations between each of the five species under study.

Sufficient positive reactions were obtained in each case to warrant the conclusion that the organism responsible for bacterial wilt of tobacco in Puerto Rico is equally pathogenic to the other hosts under consideration and they, in turn, are equally pathogenic not only among themselves but also to tobacco.

Varietal Susceptibility.

Through the courtesy of Dr. R. F. Poole, of the North Carolina State College of Agriculture, the writer received seed of three flue cured varieties of tobacco: Cash, White Stem Oronoco and Adcock, known to be susceptible to bacterial (Granville) wilt. When tested, the Adcock seed failed to germinate.

In the Summer of 1931, 200 plants of each of the Cash and Oronoco varieties were grown in a field known to be heavily infested with the organism, as demonstrated by the high incidence of infection when either tomatoes or susceptible eggplants were grown on it. They were planted alternately in 10 rows, 3 ft. apart, 40 plants to a row. Hot, rainy weather followed for weeks after transplanting to the field. A perfect stand was secured by continued replantings. Notes on incidence of wilt were taken once a week, as soon as the first symptoms * were observed. The results are given in table 1.

* Before finally recording any plants showing symptoms as positive, a critical examination for bacterial exudate was made.

TABLE I

INCIDENCE OF WILT ON TWO IMPORTED TOBACCO VARIETIES

Variety	Population	Healthy	Wilted	% Wilted
Cash	200	87	113	56.5
White Stem Oronoco	200	53	147	73.5

The results demonstrated that these varieties are highly susceptible to the disease under favorable conditions for infection.

A more extensive trial was conducted in the same field early in the Spring of 1932. Besides the above mentioned types, our three most popular varieties: Virginia, Ceniza and Utuado, and a vigorous variety brought from Colombia in 1929 by Dr. J. A. B. Nolla, were included in the test. The same plan of planting as explained in the previous trial was followed. The weather was cool and dry at the time of planting and remained so for two or three weeks after. In consequence, the plants failed to grow rapidly and the symptoms of bacterial wilt appeared very late, even at flowering time with the early varieties. Symptoms of fungus wilt, however, showed much earlier and to such an unexpected extent that it became obvious that this factor had to be taken into consideration in analyzing the results. These are given in table 2.

TABLE II

INCIDENCE OF FUNGUS AND BACTERIAL WILT ON LOCAL AND IMPORTED TOBACCO VARIETIES

Variety	Population	Plants infected with fungus wilt *	Percent infected with fungus wilt	Plants infected with bacterial wilt	Percent infected with bacterial wilt from total No. of plants	Percent infected with bacterial wilt from healthy plants only **
Virginia	180	39	21.66	15	8.33	10.63
Utuado	201	22	10.95	18	8.99	10.06
Ceniza	202	65	32.12	13	6.43	9.48
Cash	201	98	48.75	23	11.44	22.33
Oronoco	204	63	30.88	46	22.54	32.62
Ambalema	212	33	15.56	30	14.15	16.75

* *Rhizoctonia solani* Khün and *Phytophthora parasitica* var. *nicotianae* Tucker.

** The per cent of bacterial wilt from healthy plants only, i.e., from those remaining after deducting the ones infected with fungus wilt.

The writer is inclined to consider the percentage obtained in the last column as a more accurate estimate of the true incidence of infection for each variety under the conditions of the experiment because the early invasion of plants attacked with fungus pathogenes prevented the infection with *B. solanacearum*, which, as stated, developed much later in this particular trial. Furthermore, not a single plant attacked with fungus wilt was found to be also infected

with bacterial wilt, when such a condition ought to have been possible had every plant had an equal chance of infection with the bacterial pathogene.

The results show that tobacco varieties exhibit a wide range of susceptibility to the disease and that, even under conditions of high soil infestation, our standard varieties are highly resistant to the disease. The Ambalema is less so and the North Carolina varieties very susceptible. Furthermore, our standard varieties, although exhibiting unmistakable signs and symptoms of the malady, were able in practically every case, to recover rapidly without any appreciable loss and the same is true, although to a lesser extend, of the Ambalema. Both the Cash and White Stem Oronoco varieties presented not only more severe symptoms of a progressive nature, but in the majority of cases every diseased plant was an actual loss.

With repect to the two last-mentioned varieties, the results are in harmony with those presented in table 1. The fact is also brought out that the disease is much more severe during hot, rainy weather than during the cool, semi-dry season. Because tobacco is grown in Puerto Rico under the last mentioned conditions another reason for the rare occurrence of the disease in commercial plantings in presented.

Discussion.

The systematic position of the organism responsible for bacterial wilt of tomato, eggplant, pepper and potato in Puerto Rico has been repeatedly questioned, because although morphologically and physiologically similar to *B. solanacearum* E. F. S., it has been found unable to infect tobacco under natural conditions or when artificially inoculated. In the Summer of 1931, the writer found a natural case of wilt in tobacco exhibiting symptoms very similar to the so-called Granville Wilt in the United States. Cultural studies of the organism involved identified it as similar to the ones isolated from other known suscept. Extensive direct and cross-inoculations with the exudate characteristic of the disease established its pathogenecity and intertransmission. Agar plates of this exudate yielded either pure cultures of an organism morphologically and physiologically identical with *B. solanacearum* E. F. S. or mixed colonies from which the organism was readily isolated. In the light of these results and of previous studies of Smith (l.c.) and Nolla (l.c.) when studying Puerto Rican material, it is concluded that *B. solanacearum* as occurs in Puerto Rico is identical to *B. solanacearum* as described by Dr. Edwin F. Smith.

The life history of the organism and suitable control measures were not included as a part of these studies because these phases of the problem have been adequately treated by other investigators here and elsewhere. The writer is of the opinion, however, that invasion of tobacco under our conditions very seldom, if ever, takes place through the aerial parts of the plant, but through the underground parts. In hundreds of wilted plants examined, the advance of the infection could always be traced from the roots towards the stem and never in the opposite direction. Aerial inoculations on peppers, however, have been successful.

Rotation of crops as a mean of control seems to have very limited, if any, possibilities. In fact, the first case of tobacco wilt was found in a field which has been growing sugar cane for many years. A field test of four varieties of tomatoes in a field not planted with any Solanaceous crop for at least 15 years, was a complete failure because more than 40 per cent of the plants were killed by the disease.

Breeding for resistance is, undoubtedly, the most promising control measure. Nolla (l.c.) found some varieties of eggplant and pepper highly resistant to the malady. Under our conditions the variety of potato Red Bliss Triumph is very susceptible while the Irish Cobbler, when grown under similar conditions, is very resistant. Tobacco varieties have shown a wide range of resistance. It is only in tomatoes that a resistant variety has not been found.

ACKNOWLEDGMENT.

The writer wishes to express his thanks to Dr. Melville T. Cook, Chief of the Division of Phytopathology, for his unfailing encouragement during the course of this investigation and for the revision of the manuscript.

LITERATURE CITED.

(1) **Cook, Melville T.**—A bacterial wilt of eggplants. Journal Dept. Agr. Puerto Rico **8** (4): 14–16. 1 fig. 1924. Also in Phytopath, **15**: 55 (Abstract) 1925.

(2) **Henricksen, H. C.**—Vegetable Growing in Porto Rico. Porto Rico Agr. Exp. Sta. Bul. **7**: 1–58. 1906.

(3) **Iorns, M. J.**—Report of the Horticulturist. Porto Rico Agr. Exp. Sta. Ann. Rpt. **1907**: 20–30. 1908.

(4) **López Santiago, B.**—Algunas enfermedades del tomate en Puerto Rico. Revista de Agricultura de Puerto Rico. **9**: (6) 33–37, fig. 1–2. 1922.

(5) **Nolla, J. A. B.**—Studies on the Bacterial Wilt of the Solanaceae in Porto Rico. Journal of the Department of Agriculture of Porto Rico **15**: (3) 287–308. 4 plates. 1931.

(6) **Seaver, Fred J.** and **Carlos E. Chardon.**—Botany of Porto Rico and the Virgin Islands. Mycology. Sci. Surv. of Porto Rico and the Virgin Islands, New York Ac. Sc. **8**: 1–208. **1926.**
(7) **Smith, E. F.**—Bacteria in Relation to Plant Diseases. Carnegie Inst. of Washington, Publication 27, **3**: 1–309, 1914.
(8) **Stevenson, J. A.** and **R. C. Rose.** Vegetable Diseases. Porto Rico Ins. Exp. Sta. Rept. **1916–17**: 85, 87. 1917.
(9) **Stevenson, J. A.**—A check List of Porto Rican Fungi and a Host Index. Jour. Porto Rico Dept. Agri. **2**: 125–264. 1918.
(10) **Stanford, E. E.** and **Wolf, F. A.**—Studies on Bacterium solanacearum. Phytopath. **7**: (3) 155–165. 1 fig. 1917.
(11) **Thomas, H. E.**—Report of the Plant Pathologist. Porto Rico Agr. Exp. Sta. Ann. Rept. **1917**: 1–40. 1918.

Explanation of Plates.

Plate I.—Two nutrient agar plates using different dilutions from a broth culture made directly from tobacco ooze. Only typical colonies of *B. solanacearum* developed. This ooze was used to inoculate plants shown on plate II.

Plate II.—*Upper:* Plants of the "Ceniza" variety artificially inoculated with bacterial ooze from wilted tobacco plants, photographed 10 days after the inoculation. Plants at left and right are showing typical symptoms. Middle plant, check.

Lower: Same as above using plants of "Utuado" variety.

Plate III.—At left naturally wilted plant and at right healthy plant of the imported variety "Cash".

PLATE I.

PLATE II.

PLATE III.

CONCERNING THE ORIGIN OF THE WHITE QUARTZ SANDS OF NORTHERN PUERTO RICO

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There are numerous deposits of white quartz sands of varying depths which are distributed in belts and spots from a few miles southeast of San Juan to a point about 4 miles southeast of Quebradillas. The largest deposits occur between San Juan and Manatí. Nearly every scientist who has observed these sand deposits has conjectured as to their origin and several have offered tentative theories. Most writers have merely mentioned them without attempting to offer an explanation of how they were accumulated.

The writers had the opportunity to study these white sands in great detail while making a soil survey of the districts in which they occur in abundance. We herewith submit our findings and we believe that we have been able to explain, at least in part, the methods and forces which have caused the accumulation of these deposits.

For the benefit of those unfamiliar with these sands a brief description of them and their environment is in order. The "white sand" deposits consist of white or gray quartz sands which vary in depth from a "smear" of a few inches to dune-like deposits 15 feet or more in thickness.[2] Usually the surface six or eight inches of these sandy areas will be light gray colored while the subsoil will be nearly white. In many places the water table is reached at from 20 to 50 or more inches depth. In these places the white sands are

[1] The authors are indebted to the Director of the Insular Experiment Station, Mr. F. A. López-Domínguez and assistants Messrs. Jorge Landrón and David Rodríguez for their helpful cooperation in the prosecution of the soil survey of the north coast which furnished the basis for much of the contents of this paper. We are also greatly indebted to Dr. N. L. Britton of the New York Botannical Garden, Chancellor Carlos E. Chardón of the University of Puerto Rico, and Dr. H. A. Meyerhoff of Smith College for valuable suggestions. Dr. C. F. Marbut, Chief, and Mr. Mark Baldwin, Inspector, of the Bureau of Chemistry and Soils furnished valuable criticism and suggestions which have greatly added to the value of the paper. Messrs. Ray C. Roberts and A. T. Sweet, of the U. S. Bureau of Chemistry and Soils; and Messrs. Juan Zalduondo and Fernando A. Villamil of the Insular Experiment Station furnished soil maps of the San Juan district which were of great use in studying the distribution of white sands in that region.

[2] Cook and Gleason (3) in their "Ecological Survey of Puerto Rico", published in the July, 1928, issue of the Journal of the Department of Agriculture of Porto Rico, describe the white sands in part as follows: "The soil is composed of white, *calcáreous* (italics ours) sands of unknown depth." As a matter of fact these white sands are practically pure quartz and their acid reaction demonstrates that they are distinctly non-calcareous. Possibly the sands were confused with nearby shell sands which are highly calcareous. It is commonly believed among the farmers of the northern coastal region that these sands consist of limestone grains.

underlain by a heavy, columnar and highly acid clay which is exceedingly difficult to penetrate with digging tools. This clay is usually gray in color with streaks and blotches of bright red or yellow or both. The thickness of the clay varies and is known to be more than 15 feet deep in places. The cracks and root holes are usually lined with white leached clay (probably kaolin). The sand, where it contacts the clay, is usually stained dark brown or dark gray and is often cemented into a "hardpan". Superficial observation would lead one to believe that this cementing material consists of iron oxides (limonite) but if the "hardpan" is ignited the dark color disappears and leaves a white or sometimes a pale yellow sand. It is evident, therefore, that the cement is of organic material. In a few places it was observed that the hardpan layer was partly of iron and partly of organic material. When the hardpan from these latter places is ignited the organic part of the cement burns out and the residue, owing to the effect of iron oxide, assumes a light red or or pinkish color.

The underlying clay material, when it is exposed in a ditch bank or road cut, exhibits a strong tendency to form vertical columns. These columns break up into well defined prisms of varying sizes which are very hard when dry and exceedingly stiff and resistant to pressure when moist. In the wet condition a good degree of plasticity develops.

There are many places where the white sands lie on knolls or on gently sloping hillsides and a few places where the slope is quite steep. At first sight one would expect that the natural drainage would be good or even excessive in these places. This is frequently true but in many apparently well drained areas there is a heavy, tight clay like that described above which holds up the descending waters after rains and causes the lower layer of white sands to be wet much of the time. In these places, just as in those described in the foregoing an organic hardpan forms. The places where the white sands have good subdrainage do not have well developed organic hardpans and in some places even dark organic stains are lacking.

Where the white sands are deep they tend to blow up into low dunes and to spread out into layers of varying thickness over adjacent soils. In places where the latter has occurred one does not, of course, find the normal profile development.

All of the sands observed occur within the belt of land where the Tertiary limestone forms the bedrock. Britton (1), Chardón and others have suggested that these sands may be the residuum left

from the weathering of these limestones. There is much evidence to support this hypothesis. The Tertiary limestones have been weathered in a manner peculiar to the tropical regions. Except for small areas where the large rivers have cut their way through from the interior of the island, surface alluvial erosion is negligible. Underground streams remove most of the water which falls on the Tertiary limestones and these streams are fed by water which seeps down through the porous limestone and sinkholes. Differential solution of the limestones has led to the formation of myriads of "solution valleys" and intervening *"mogotes"*, *"pepino"* (cucumber), or "haystack" hills. These "haystack" hills are closely spaced in places and in other places stand out in isolated groups or in rows in the larger open valleys.

Where the white sands occur in "solution valleys" which are entirely surrounded by high hills there is no other probable source for them than the limestone itself. There seems to be little if any doubt that this is the case. The writers, with this in mind, made a large number of observations to see whether the limestones contained quartz sand in sufficient quantities to account, not only for the white sands but also for the sands which occur in the valley soils which are red, brown, or yellow in color. It was found that there are many layers of limestone which contain more or less sand and there are a few thin interstratified layers of clays and sands which contain little or no lime. Dr. Britton (1) once observed sandy layers in the limestones near San Juan and our more extensive observations have confirmed his findings. Places where these sandy layers may be easily observed are in the vicinity of Almirante; six miles southwest of Arecibo on the Lares road; 4 and ½ miles southeast of Hatillo; and on the Camuy River trail 5 and ¼ miles southeast of Camuy, 300 yards before the river is reached. In the latter place there is a 3 or 4 foot thickness of limestone which, perhaps, contains as much as 30 per cent of quartz sands. A sample of decayed limestone from 4 and ¼ miles southeast of Hatillo was examined by Fry of the U. S. Bureau of Chemistry and Soils and he estimated that it contained 25 per cent of quartz sand. The sandiest soils of limestone derivation and the areas of white sand were observed in the localities where it was definitely determined that the limestones contained appreciable quantities of sand. This is by far the most plausible explanation of the origin of the white (and other) sands of the localities which are *remote from the seacoast.* The dissolving of great thickness of these limestones would readily account for the accumulation of sands in the "solution valleys". It might be observed in passing

that the sandy limestones occur in the transition zone between the youngest of the Tertiary beds and the second youngest. These different divisions have been described by Hubbard (**5**), Meyerhoff (**9**) and others. Meyerhoff [3] suggests the possibility of artesian springs bringing up the sands from underground, but we observed no place where this would seem to be a plausible explanation.

The largest beds of white sands occur fairly near the seacoast at distances varying from ½ mile to 2 and ½ miles. The limestone hills between them and the ocean are often quite low and rounded and in many places it seems quite possible that sands from the beaches may have been blown over the hills by the prevailing northeast trade winds. One of the largest deposits occurs 1 and ⅕ miles southwest of Arecibo. In this place the sands occur intermittently over a large U-shaped area the two arms of which extend in a west-southwest direction. Over most of this area the sands lie on a nearly common level and comprise flattish bench-like deposits. Numerous deep sinkholes indent this flattish area and it is surrounded by low-lying, rounded limestone hills. A few of the white sands in this district are on the tops of low rounded knolls and above the average level of the main body. The sands of the northern arm and eastern end of this area grade into acid brown sands which are frequently underlain by heavy clay subsoils similar to those under the white sands. Several large areas of the brown sands have a sandy iron hardpan layer between the soil proper and the subsoil. These acid brown sands, in turn, grade into alkaline brown quartz sandy soils as the coast is approached. These latter sands are without doubt largely derived from the disintegration of the San Juan consolidated sand dunes the sands of which are being broken apart by the waves on the seacoast and spread inland by the trade winds. It should be remarked for the benefit of those not familiar with the San Juan sand dunes that they were originally piled up by the trade winds on a bar near the shore and have subsequently been cemented by lime. This cement was very probably formed by a deposition of lime which resulted from the evaporation of sea spray. Some of the lime may also have come from the solution and redeposition of the lime of sea shell fragments. Probably the acid brown sands which are farther inland than the alkaline sands were largely derived from the sands which have spread inland from the coast through the agency of wind. They are acid because the leaching of the lime in them

[3] In 1931–32, Dr. H. A. Meyerhoff of Smith College, delivered a series of lectures at the University of Puerto Rico. These lectures are to appear in book form at an early date and their author very kindly permitted us to read the manuscript.

has exceeded the rate at which the limy material from the coastal sands has been supplied. At the present time there is very little transportation of material taking place because of the fact that grasses and bushes are holding the sand in place.

It may be readily surmised from the above that at least a part of the white sands near Arecibo have been derived from brown sands which have been blown inland from the coast. The present pale gray or white color is due to excessive acid leaching by ordinary soil forming processes. These processes will be discussed later in greater detail.

Another possible explanation of the presence of a large body of white and gray sands near Arecibo is that there may have been an old lake, swamp or estuary in this locality and the sands may have been deposited along its shores or on the bottom. A deposit of white sands now borders Laguna Tortuguero farther to the east. The great thickness of heavy mottled clay under the white sands lends credence to this theory. Another evidence to lend support to the theory of an old estuarine or lake deposition is the fact that it is well known that the coast line between Arecibo and Aguadilla has been much lower in the past. High wave-cut terraces are to be discussed in Meyerhoff's "Geology of the Arecibo District" so we shall not discuss them further here.

In many places between Manatí and San Juan the deposits of sand are very deep and in many of these places there is unquestionable evidence that they have been reworked by the wind since original deposition.

Between San Juan and Carolina there are deposits of white sands surrounding swampy and mucky areas where the evidence seems to be in favor of lagoon shore deposition. Granting the idea of some of the sands having been old beaches we still may be permitted to wonder from whence the sands were originally derived. We may still logically suppose that a fair share of them came from the dissolution of the Tertiary limestones and perhaps a part of them from the weathering of the nearby San Juan formation. If we must go back to first beginnings the quartz grains doubtless came from the weathering of granites and other siliceous rocks of the "oldlands" of the interior. The rivers carried the sands down and the waves and currents spread them out over the Tertiary sea when the limestone strata were being built up.

Up to the present point in our discussion we have devoted our remarks almost entirely to the explanation of the different probable sources of the white sands with scarcely any mention of why they

are *white* instead of brown, yellow or red like the other sands with which they are closely associated. The answer to the latter question is one which may be best referred to soil science. Soils quite similar to the white sands of Puerto Rico occur abundantly in the southeastern coastal plains of the United States. They are especially abundant near the Atlantic seacoast in Georgia and Florida but occur in scattered localities somewhat farther north than Lakewood, New Jersey. The areas of white sands in Puerto Rico which have a high water table are very much like the *León* and related sands of the coastal plains of Georgia and Florida, while the deeper sands are much like the *St. Lucie* soils of Florida. The shallower types, which are well drained, resemble the *Lakewood* sands which are distributed from New Jersey well into the southern states. Hearn (**4**) estimates that there is a total area of about 4 or 5 million acres of the *León* sand alone. This is about twice the total area of Puerto Rico. The *Lakewood* and *St. Lucie* soils in their turn occupy a tremendous additional area. Cobb (**2**) observed similar sands in France and Bennett found a few areas of *León* sands in Nicaragua. It should be plainly understood at this point that there are several minor points of difference between the different types of white sands in Puerto Rico and the similar types on the United States mainland. We cannot, therefore, call them by the same names. Soils of the *León* series are characterized by a dark gray, strongly acid, sandy surface about 4 inches thick, about 18 inches of white quartz sand and a 10 inch organic hardpan just above the water table which occurs at about 32 inches from the surface. Beneath the hardpan there is normally a loose wet yellowish sand to considerable depths. In some places, however, the hardpan is underlain by a stiff mottled clay just like the clay layer underlying much of the Puerto Rico white sands. The deeper white sand deposits of Puerto Rico more closely resemble the *St. Lucie* sand of Florida which consists mainly of a loose, white quartz sand to great depths. This sand also has an organic hardpan or at least streaks of dark organic matter at or near the water table level if the latter occurs within the sand itself. It may be easily seen from the foregoing that white sands similar to the sands of Puerto Rico are very well known indeed in other parts of the world.

The general processes by which soils of this type are formed are well known. Marbut (**6**) speaks of the *León* sands as "ground water podzols" and of the *Lakewood* sands as true podzols. Typical podzols or "ashy gray" soils are formed in well drained areas under a humid climate and usually under a conifer forest cover. They are characterized by a surface mulch of semi-decayed organic debris such

as pine needles, leaves, rotten wood, etc.; an ashy gray or nearly white "leached horizon"; a B-horizon or accumulated iron, clay and organic matter and the underlying parent rock. "Ground water podzols", such as the poorly subdrained types of white sands in Puerto Rico, usually occur only where the parent materials are originally very sandy and where the water table is relatively high, or in other words, where subdrainage is very poor. Until quite recently it has been believed by most soil scientists that true podzols can be formed only in a cool temperate region but Marbut (6) has shown that the *Lakewood* sand is a true podzol and it extends well into the warm temperate regions of the south. It is significant, however, that only the very leachy sandy soils have thus far been proved to form typical podzols outside of cool temperate regions. True podzols derived from heavier materials, have been thought to be confined largely, if not entirely, to humid cool temperate regions, either in high latitudes or at high altitudes in low latitudes. Abundant evidence of podzolization in many parts of Puerto Rico from sea level to 3,000 or more feet above the sea, have proved that the process is active here and it is possible that small areas of true podzols from heavier materials than sands may be discovered. A bit of evidence along this line will be discussed later in this paper.

Probably much more than half of the white sands of Puerto Rico are "ground water podzols". Hearn (4) in a paper read before the eleventh annual meeting of the American Soil Survey Association, November, 1930, has given a good review of the formation of the *León* type of soil profile, which so closely resembles the ground water podzols of Puerto Rico. He laid special emphasis on the formation of the organic hardpan, which, before analyses were made, was thought to consist of oxides of iron. Briefly, the original material is very sandy and contains only very small percentages of silts and clays. The silts and clays are removed by the downward percolation of meteoric waters. This process is known as "eluviation" and it is aided and hastened by the colloidal organic acids produced by the decay of plant remains. These acids act as solvents for colloidal iron stains which lend ordinary quartz sands a red, yellow or brown coloration, with the ultimate effect of bleaching the sands white. Colloidal organic matter is formed by the work of bacteria which cause the decay of dead roots and leaves of plants in the soil proper. Much of this material is precipitated at the level of ground water forming the organic hardpan. The mass of hardpan is greatly increased by the presence of plant roots which accumulate at the level of ground water. In the southeastern states one of the commonest

plants is the sawtooth palmetto and its roots have been observed to be concentrated in the hardpan. On some of the white sands of Puerto Rico the corozo palm is quite common and it is quite possible that its roots, as well as those of other plants, have contributed to the hardpan.

We may then offer the following suggestions as to the formation of the poorly drained white sands of Puerto Rico. First we start with a soil material which contains a very high to fairly high percentage of silica sands. This sandy soil will lie in a fairly flat position and must either contain an impervious layer beneath or must contain material which may later be used by the soil forming processes to cause conditions of poor drainage. Poor drainage may, of course, also be caused by a high water table which has been brought about by proximity to sea or lake level. There must be some vegetation to furnish organic material to be used by the soil in forming acids, and there must finally be a humid climate to furnish the necessary leaching waters.

In the case of the largest deposits of the sands the original material seems to have been derived partially as a residuum from dissolved slightly arenaceous limestones and partly a subaerial accumulation of sands which have been carried inland from the wave-shattered San Juan sandstone formation. There is some evidence that some of these sands are littoral deposits which have remained after a slight withdrawal of water of the sea and lagoons in recent geological times. It seems almost certain that these larger deposits of sandy materials were locally transported by wind or water or both and deposited on the gray clays of lowlands possibly formerly occupied by lagoons, estuaries or sinkhole ponds. This gray clay furnished the necessary conditions of poor drainage. Vegetation occupied the soil and the leaching of the minor amounts of silts and colloidal materials proceeded at a rapid rate. In many places, typically a short distance southwest of Arecibo, there is a regular transition from highly leached white sands, through gray-brown acid sands to alkaline sands, proceeding toward the seacoast. All of the white sands are far enough from the sea to be almost entirely unaffected by the spray from the breaking waves which are piled up by the trade winds. Soils in this district so affected are universally alkaline in reaction. In such a leaching process any soluble salts disappear first, then the less soluble calcium carbonate and finally, after the decaying organic matter lends an acid condition to the soil, the other soil pigments are dissolved and carried out by the ground water. The poor drainage causes the iron to be reduced to the fer-

rous state which makes it much more soluble. In places where the parent sands contain larger amounts of iron and alumina than normal these materials are mixed with the hardpan.

The above description of the formation of white sands covers a very large total area of these soils. Many places having apparent good drainage, if one were to judge by surface appearances, in reality have a fairly high water table which usually lies just above the heavy clay layer. It is probable that most or all of the sands of these places should be classed as ground water podzols. There are many other places, however, where subdrainage as well as surface drainage is sufficiently good to throw the white sands into the class of true podzols which form only under normally good drainage conditions. Until very recently it had been considered by most soil scientists that it is very improbable that true podzols would be found in tropical lowlands. Marbut [4] and Affanassief and others have found evidences of podzolization in the tropical lowlands and they have predicted the possibility of the existence of true podzols in this position. We are unaware of such podzols having actually been found in tropical lowlands until last year when the white sands of Puerto Rico were thoroughly studied in the field. From a morphological standpoint the well drained white sands which we shall briefly describe below are unquestionably true podzols in the same sense that the *Lakewood* sands of New Jersey are true podzols. We fully expect that chemical analyses will confirm the morphological identification.

If the process of true podzolization is to account for the formation of the well subdrained areas of white sands it would be reasonable to suppose that the same types of deposit might be formed from different materials with different thicknesses of the product and with a large number of gradations between the typical white sands and other soils with which they are associated. One type of such gradation has already been mentioned. In those deposits occurring well within the limestone hills and several miles distant from the seacoast one of the commonest associations of white sands is with a group of soils known provisionally as the *Vega Alta* series. This series of soils has grayish brown surface soils with compact but moderately well drained, coarsely mottled red, yellow and gray subsoils, the former two colors predominating. The heavier types of this series, such as the clay and clay loam are more brown than gray in the surface but the sandier types become grayer with the increase in the percentage of sand present. In many cases the soil surveyor is puzzled as to whether to group these grayer sandier types of soils with

the *Vega Alta* series or with the shallower types of the white sand group. With the graying of the surface horizon there is sometimes a tendency for the subsoil to become more poorly drained. This change in the drainage conditions seems to have been brought about by the eluviation-illuviation process. The clays and colloids have been eluviated from the surface by meteoric waters and deposited in the interstices of the subsoil forming a layer of illuviation. This process slows up drainage and may in many cases ultimately result in the formation of a temporary shallow water table at which an organic hardpan begins to form. This gives rise to the ultimate formation of the ground water podzol type of white sand. On the other hand there are many places where the subsoil retains sufficiently good drainage to take care of the meteoric waters. One such area lies some distance south of Sabana Hoyo far within the limestone hills in association with soils of the *Vega Alta* series. It has the grayish white surface and white upper subsoil but lacks the organic hardpan. The underlying clay is typical of the *Vega Alta* series of soils and is therefore well drained. The upper subsoil, as in the case of the *Vega Alta* soils, has accumulations of iron and alumina in addition to small amounts of colloidal organic matter. The area occurs on the top of a sharp knoll and is unquestionably a typical sandy podzol. There are several small areas like this one southwest of Arecibo and scattered elsewhere throughout the northern coastal region in association with ground water podzols. Gradations between true podzols and the sandier types of the red *Bayamón* and *Espinosa* soil series are quite common. These red soils also grade into the ground water podzols. The very deep areas of white sands usually are more or less piled up by the trade winds and since they are so loose and dry in their upper horizons it is frequently impossible to determine whether they have water in the lower horizons and whether they have developed organic hardpans. It is altogether probable that part of these deep areas belong to the true sandy podzols and part to the ground water podzols. From the standpoint of agriculture or of commercial use of the sands this problem has no bearing. It is a matter of purely scientific interest.

While we are discussing the sandy podzols it might be of interest to add a further word regarding podzolization in Puerto Rico. A very large total area of soils in the lowlands as well as in the highlands exhibit strong morphological evidences of this process. Many of these areas are of the heavier type of materials such as silts, sandy clays and perhaps clays in places. An extreme example of such soils very recently observed on a low hill near the new pier at Mayagüez

is a silt loam with most of the morphological characteristics of a true podzol. We can at least be safe in saying that it is a very strongly podzolized soil. Rainfall is about 80 inches per annum and natural drainage is good. A description in outline form follows. It should be noted that the land has been cleared so that the original leaf mould has been destroyed.

Horizon	Depth	Description
A_1	0″ — 4″	Light brownish gray silt loam when dry. Pale yellowish brown when wet. Medium granular structure.
A_2	4″ — 10″	When dry grayish white; when wet pale yellow floury silt loam. No evident structure.
B	10″ — 30″	Heavy reddish brown and yellowish brown clay containing many tuff and shale fragments. Very stiff when moist. All surfaces of cleavage planes are light gray and silty and gray silt follows root channels.
C	30″ down.	Loose subangular gravels of tuffs, shale and cherty fragments. Possibly an old terrace remnant or elevated beach line.

This area is very small but we believe it to be a significant evidence of the progress of podzolization at low elevations in the tropics. It is of interest to know that this highly podzolized soil occurs within two miles of the largest body of typical ferruginous laterite in Puerto Rico. A number of other places having very similar soils have been observed and it is hoped they may be discussed more fully in a later contribution. We return to the white sands after this short digression.

These white sands in their present position must be considered as very recent deposits from the standpoint of geology. They are certainly younger than the San Juan formation since in no place observed do the San Juan sandstones overlap them. Recent as they are geologically, they are quite old from the soils standpoint. The age of a soil is not measured by the number of years since the weathering forces first started working on its parent material but by the degree of leaching and eluviation which have taken place. An old soil is one in which leaching and eluviation are far advanced. In the case of sands this can take place in a much shorter time than with soils of heavier texture or with those which are high in lime. It is certain that these "old soils" (the white sands) are younger in years than many of the "young soils" of Puerto Rico many of which are so highly valued by the farmers.

It is interesting to notice that there are no white quartz sands west of the Río Guajataca, at least not in the north coastal belt. There are plenty of brown quartz sands which would theoretically be capable of weathering into the white variety but this weathering has not taken place. There is a good reason for this. The rainfall from Camuy to the northwestern corner of the island averages considerably less than 60 inches per annum. A rainfall of 55 inches in Puerto Rico is approximately the dividing line between a humid and a semi-arid climate. Such a rainfall in this part of the tropics might at least be designated as sub-humid. The formation of large areas of white quartz sand requires the leaching effects which can be produced only by a humid climate, hence the disappearing of these deposits in the northwestern part of the island.

A few miles southeast of Humacao large quantities of loose, fine quartz sands and gravels have been washed from nearby quartz-diorite hills and deposited on the sea level estuarine clays of the Río Candelero delta. These very recent deposits have already begun to show signs of leaching under the influence of a heavy rainfall and poor underdrainage. The sands and gravels are changing from brown and yellowish brown to a pale yellowish color. Incipient organic and iron deposits near the level of ground water prognosticate a future development of hardpan similar to that in some of the white sands we have been discussing. The entire island has not yet been covered in detail and it is reasonably possible that very small deposits of white or gray sands somewhat similar to those of the north coast will be found in the humid regions which have not been thoroughly explored.

SUMMARY

The origin of the large deposits of almost pure white quartz sands which occur within the area occupied by the Tertiary limestones of northern Puerto Rico have long been a source of puzzlement to geologists. The largest areas occur within a mile or so of the seacoast in association with Tertiary deposits but are unconformable with them. Many of them are found in association with the remnants of lagoons which were cut off from the sea by the San Juan formation. Some deposits are also in fairly close association with the latter formation in some places. Smaller areas occur well within the limestone hills.

Examinations of limestone outcrops and of residual soils within the limestone hills indicate that a large amount of sand originally came from the solution of layers of impure limestone which formerly

overlay the district. It is altogether probable that some of the sands have been blown inland from the broken up San Juan formation and later leached of their lime. There is some evidence to support the theory that some of these sands may have been left in or near their present position along the shore of former lagoons which have since been drained by a slight emergence of the coast. There is but little question but that the smaller deposits several miles inland and well within the limestone hills are the residuum left from the dissolution of the limestones.

The whiteness and purity of the sands are due to the soil forming process known as podzolization (acid leaching and eluviation) which in this case has taken place largely under conditions of high rainfall and poor subdrainage and to a less extent under well drained conditions. Some of the deeper deposits which are now well drained have been more or less piled up by the winds since they were bleached. We can therefore state with reasonable assurance that the quartz sands have come from the various sources above mentioned but that they are *white* because of a high degree of "podzolic" leaching which has affected them since they accumulated. Millions of acres of similar soils which have been carefully studied by soil scientists in the southeastern United States have furnished the evidence for this explanation of the origin of Puerto Rico's white sand deposits.

BIBLIOGRAPHY

1. **Britton, N. L.** Las Arenas de las Planicies de la Costa Norte de Puerto Rico. Revista de Agricultura de Puerto Rico **12**: 157, 158. March 1924.
2. **Cobb, Collier.** Lands and Dunes of Gascony. Journal of the Elisha Mitchell Society. November 1910.
3. **Cook, Melville T.** and **Gleason, Henry Allen.** Ecological Survey of the Flora of Porto Rico. The Journal of the Department of Agriculture of Porto Rico. **12**: 3–139. July 1928.
4. **Hearn, W. E.** Development of the Hardpan Layer in the León Soils. Report of the 11th Annual Meeting of the American Soil Survey Association, pp. 128–136. 1931.
5. **Hubbard, Bela.** The Geology of the Lares District, Porto Rico. Scientific Survey of Porto Rico and the Virgin Islands, 2 (part 1): 1–115. New York Academy of Sciences. 1923.
6. **Marbut, C. F.** Soils, Their Genesis, Classification and Development (Mimeographed). Lectures delivered in the U. S. Dept. of Agriculture Graduate School. Lecture 18, pp. 4 and 5. 1928.
7. ————— Comments on the Lateritic Soils in Cuba, and the Amazon Valley. Proceedings and Papers of the Second International Congress of Soil Science, Commission and Classification Geography and Cartography of Soils, pp. 79 and 80.

8. **Marbut, C. F.** and **Manifold, C. B.** The Soils of the Amazon Valley, etc. The Geographical Review. **15**(3): July **1926.**
9. **Meyerhoff, H. A.** Geology of the Fajardo District, Porto Rico. Scientific Survey of Porto Rico and the Virgin Islands 2 (part 3): 201–360. New York Academy of Sciences. 1931.

Explanation of Plates

PLATE IV

Figure 1. Area of white sand southwest of Arecibo. Vegetation consists of second growth of icaco (*Chrysobalanus icaco* L.) and pajuil or cashew-nut (*Anacardium occidentale* L.) Young cocoanut trees grow very slowly on these infertile sands.

Figure 2. Upper part of profile of white sand. Grayish surface soil slumped into pit at left center. White horizon shows plainly just under plant roots at extreme left.

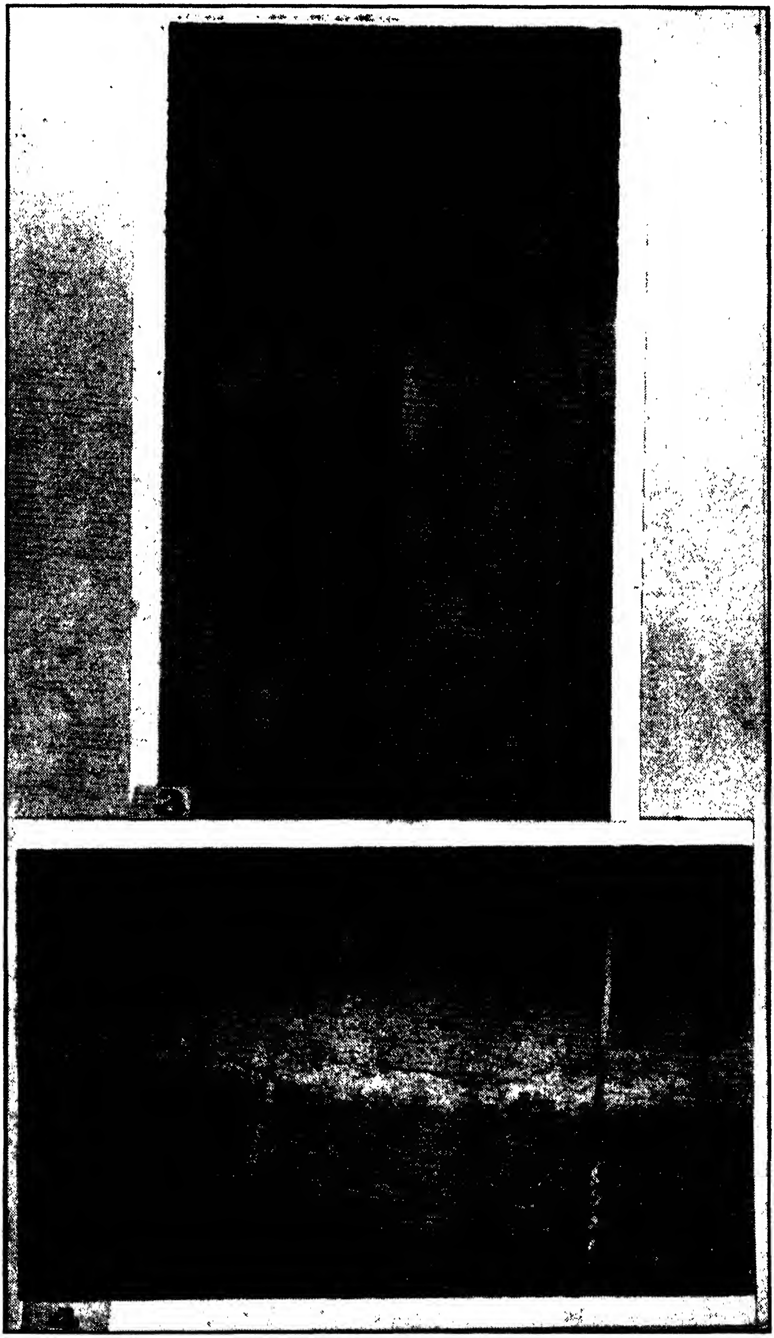
PLATE V

Figure 1. Shows heavy sandy clay which underlies many of the areas of white sands. Light colored vertical and horizontal streaks are white kaolin. Dark colored layer above is organic hardpan.

Figure 2. Highly podzolized soil profile about 4 miles south of Humacao. Soil is derived from quartz diorite and occurs near a hill top. Drainage good. Note strong development of whitish A_2 horizon just above heavy B horizon at center of photograph. Profile similar to the one described from Mayagüez and represents same soil-forming process which caused the formation of the white sands.

PLATE IV.

PLATE V.



PUERTO RICO SEEDLESS ORANGE SELECTIONS

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During the months of August and September, 1928, the senior writer visited the principal fruit-growing districts of Puerto Rico in order to study the varieties of citrus fruits grown and to introduce improved methods for the propagation of selected strains of the commercial citrus fruits. This visit was made in response to an invitation by the Commissioner of Agriculture and Labor of Puerto Rico and with the cooperation of the Bureau of Plant Industry of the U. S. Department of Agriculture. The selection and propagation study of citrus problems was cut short by a severe hurricane that occurred on September 13 and 14 but important information had been obtained before the terrific storm known locally as the San Felipe hurricane, interrupted the investigation. During the search for a superior orange amongst the so-called "wild" or seedling trees an outstanding tree bearing seedless oranges of apparent commercial value was discovered and propagated. This report will contain an account of the discovery and the description of the characteristics of this tree and its fruit and of three others that were found and propagated subsequently.

DISCOVERY OF SEEDLESS ORANGE

Upon his arrival at San Juan, Puerto Rico, in August, 1928, the senior writer met with Hon. C. E. Chardon, then Commissioner of Agriculture and Labor, at his office in the Insular Experiment Station at Río Piedras, in order to decide upon a plan for investigating citrus-bud-selection problems. At this meeting the senior writer proposed amongst other things a systematic search for superior orange trees, particularly amongst the plantings of the so-called "wild" orange trees that are located on various coffee plantations of the hill districts and in the gardens of Puerto Ricans, many of whom have shown a special interest in the planting and study of orange varieties.

During a previous visit to Puerto Rico, in 1905, the senior writer has been impressed by the marked variation in the commercial quality of the Puerto Rican oranges that came under his observation at that time. This experience together with a similar one in California citrus orchards during the past twenty-three years were the reasons that led to the proposal of study of the seedling orange trees in Puerto Rico during the Fall of 1928 from the standpoint of determining, so far as possible, the nature of variations, if any, in the trees and their fruits and particularly to look for individual trees that were apparently superior to the average for commercial propagation and culture in Puerto Rico.

A searching party was organized early in September 1928 to carry out a systematic search for a superior orange in certain citrus-growing districts of Puerto Rico. The members of the expedition consisted of Mr. O. W. Barrett, then in charge of farm demonstration work for the Puerto Rico Department of Agriculture and Labor and whose knowledge of local agricultural conditions and familiarity with the Spanish language were valuable in this work, Mr. A. Mayoral of the Plant Propagation Station at Trujillo Alto, and the senior writer. The equipment included a supply of sphagnum moss and suitable containers for budsticks in order to insure the proper care for any budwood that might be obtained from any outstanding tree that might be discovered.

Several days were spent in studying orange trees in various locations on the Island but without finding any particularly valuable orange trees of interest from the commercial standpoint. A few selections of budwood from interesting trees that were thought to be better than the average were made but these trees were considered to be of minor commercial importance by the senior writer. While the fruits of these selected trees were apparently superior in one or more commercial characteristics to the average, the fruit and foliage characters did not meet all of the requirements that were considered to be essential for a superior orange variety.

Finally, on September 11th, 1928, a visit was made to a coffee plantation owned by Don Francis Martínez, located in the hill country above the city of Mayagüez and about 1,200 feet above sea level. The orange trees on this plantation, probably more than a thousand in number, were planted for the most part alongside the coffee fields and as a shade for the coffee plants. They were about forty years old, according to the superintendent of the plantation who accompanied us during our study of these trees. They were typical so-called "wild" or mountain orange trees, i. e. apparently seedlings of

the varieties introduced by the Spanish explorers and settlers during the early history of the colonization of Puerto Rico. The principal crop on this plantation was coffee and the maintenance of the orange trees was incidental to the main business of the plantation. In addition to those planted alongside and in the coffee fields, small groups of orange trees were found growing near the houses of the employees as was frequently the case on similar plantations in other districts that were visited during the course of the survey.

At the time of this reconnaissance, the fore part of September 1928, the fruits of most of the orange trees observed were young and small, about the size of walnuts on the average. Now and then a tree was found with larger and more mature oranges while others had only very small fruits. All of the fruits examined from the most promising-looking trees contained several seeds and some of them had as many as 35 or more seeds each. In some instances the rinds were very thin and in others the peels were quite thick. Most of the oranges examined had a tender rag and were very juicy but some of them contained an excessive amount of coarse rag and were lacking in juice. In some instances the flavor of the juice was fair to good but in most cases it was insipid and poor.

Amongst the orange trees in the main border row of the Martínez plantation several apparently interesting ones were examined but upon close study they were found lacking in one or more of the characteristics essential for a superior commercial orange by reason of the undesirable shape, size, rough texture, poor flavor, lateness of maturity, excessive number of seeds or other characters of commercial importance. As a result no attempt was made to collect budwood from any of the trees that were first examined. After walking about half the length of the row, the senior writer noticed in the distance a conspicuous tree that stood out from the neighboring ones so that it attracted his immediate interest. The characteristics of this tree that were particularly noticeable to the senior writer while still some distance from it, included: an unusually large crop of apparently mature oranges having uniformly desirable commercial size and shape, the relatively large size of the tree and its dense, deep green foliage with large, clean, healthy appearing leaves. Instinctively, the senior writer felt at the time that this might be the tree for which he had been searching, but restrained his enthusiasm until it was possible to examine the foliage and the fruits more closely.

Upon reaching the conspicuous tree the senior writer picked an orange nearest at hand and cut it traversely across the mid section. The first glance at the cross section showed that the orange has a

medium thickness of peel, the flesh was firm and had an attractive texture and color, the core was very small and solid and no seeds were visible. Small sections were immediately cut from the two halves and handed to members of the party. After tasting these samples everyone present agreed that the flavor of the juice, texture of the flesh, and the bouquet or aroma of this fruit was superior to any of the samples tasted heretofore on this trip or to the best of their recollection in any previous tests. The fruit was found to be entirely without seed or any evidence of seediness. The senior writer then cut, in a similar manner, 24 other oranges that were picked from different branches of this tree and every one without exception proved to have very similar characteristics to those of the first one examined, including absence of seeds, firm and very tender flesh, no apparent core, an abundance of excellent flavored juice, medium thicknesss of rind and exceptionally desirable size and shape of orange from the commercial standpoint. The unanimous opinion of those present was that this was the best eating orange that they had tasted to the best of their recollection.

About 50 budsticks were then cut from this outstanding tree, each with one or more typical fruits attached. The fruits were cut off from the budsticks and their characteristics noted, particularly the absence of seeds. The budwood was carefully labelled and immediately packed in moist sphagnum moss. A few additional oranges were also picked from the tree for subsequent examination.

The remaining orange trees in the row were looked over before the party left the plantation but nothing of particular interest was observed. By this time darkness precluded any further field studies and the party returned to Mayagüez for the night. On the morning of September 12, 1928, a visit was made to several Mayagüez gardens and the party started on their return trip to San Juan. En route a stop was made at San Sebastián where several small garden orange plantings were looked over. One of the growers reported an orange tree located on his coffee plantation some distance from the city that produced characteristically seedless and desirable fruits. Arrangements were made to visit this planting subsequently in order to obtain further data and budwood for possible propagation but owing to circumstances the senior writer was unable to carry out this plan.

While at San Sebastián during the afternoon of September 12th one of the growers mentioned the fact that a hurricane had been reported from the Virgin Islands and that it was apparently approaching Puerto Rico. Accordingly haste was made to return to San Juan, but a short stop was made at Garrochales in order to visit one

of the larger Grape Fruit orchards. While at Garrochales showers began to fall and the southwestern sky developed a leaden or coppery appearance that indicated, according to the experienced members of the party, the approach of a hurricane. San Juan was reached late in the evening of September 12th and about midnight the hurricane arrived, the first stages of which consisted of terrific gusts of wind that were accompanied by a torrential downpour. On the following day the hurricane persisted until about five o'clock when a calm period occurred. Later, about nine o'clock in the evening, the wind began to blow again with hurricane violence, tho not so strongly as during the first phase of the storm, and continued until about eight o'clock of the morning of September 14th. On the following day, September 15th, the buds from the outstanding Martínez Orange tree were inserted in seedling rootstocks in propagating grounds and nursery located at Trujillo Alto, near San Juan. The leaves of the young rootstocks had been badly whipped by the violent windstorm but the seedlings were still in fairly satisfactory condition for budding on account of the fact that they were located in a sheltered place. The young nursery trees resulting from this propagation were eventually distributed in the model farms and to growers for tests of the new variety for commercial orange production.

On account of the widespread damage to Agriculture as a result of the terrific hurricane further study of the native orange trees were abandoned for the time being and the senior writer returned to Washington, D. C. However, before leaving, the senior writer drew up a systematic plan for a study of these trees and when conditions became settled after the disaster further search was made for outstanding trees. Three additional selections have been made during recent years and descriptions of these outstanding trees and samples of fruits from them are included in this report.

In January, 1931, Edmund H. Twight, of Riverside, California, the junior author, was appointed Specialist in Fruits for the Insular Experiment Station by the Puerto Rico Department of Agriculture and Commerce. He has been instrumental in bringing together the other three Rico oranges and in collecting much of the data contained in this paper. On January 8, 1932, the senior author received at Riverside, samples of the four Rico oranges from the junior author. They were picked from the selected parent trees as noted in the description. Those fruits under California quarantine regulations were shipped to Riverside from Puerto Rico in care of the Riverside County Agricultural Commissioner, in whose office they

were examined and photographed after which they were carefully burned in order to eliminate any possibility of the introduction of insect pests or disease. In addition to the personal studies of these oranges, the senior writer obtained the services of three of the leading orange growers and packers in the Riverside district in order to secure their opinions as to the commercial value of each sample and particularly their judgment as to the most desirable one of the four varieties for a commercial orchard test. Fortunately the Agricultural Commissioners of the Southern California Counties were meeting where these fruits were examined and their opinions as to the fruit characteristics and their apparent commercial value were also obtained.

The circumference and weight of each orange in all of the samples were recorded, systematic notes were made as to the color, thickness and texture of the rinds, shape of the fruit, color of flesh, character of the rag, the amount and color and flavor of the juice, the size and nature of the core, the number of segments in a typical fruit of each sample, the number of seeds, if any, the presence or absence of a navel and the soluble solids-acid ratio of the juice of a composite sample made up from three oranges of each lot were recorded. Photographs of each sample of fruits were made but owing to the poor lighting conditions in the room where the photographing was done the resulting pictures are not as clear as would have been under more favorable conditions. Each sample was examined by all those present during these tests by tasting and thru systematic inspections of the inner and outer characteristics of the fruits. Ample time was available so that opportunity was given to study the oranges adequately and to consider their characteristics from different points of view.

Some of the outstanding characteristics of the samples of oranges were: the absence of seeds, their desirable shape, size and texture from the commercial point of view, the fine bouquet and flavor of the juice, the small amount and melting character of the rag, and the good outside color of the oranges even though they had not been washed or treated in any way in order to improve their appearance. Some smut from scale was found on most of the fruits but that could have been easily washed off. Treatment with Ethylene gas would doubtless have improved their color from the commercial standpoint, but at that time it was considered best to photograph and record the descriptive notes without any cleaning or other fruit treatment.

The writers know of only one commercial orange variety, the trees of which characteristically bear seedless fruits in the South-

west, the Washington Navel Orange, which is one of the most important orange varieties grown. For this reason, if for no other, the orange selections described in this report are of scientific interest and one or more of them are likely to be commercially important. The particularly attractive flavor and bouquet of the abundant juice, the melting and very tender nature of the small amount of rag and the desirable commercial sizes and shapes of the fruits makes them of more than ordinary interest.

Following are the descriptive notes obtained from the examination of the fruits of the Puerto Rico orange selections that were sent to the senior writer from Puerto Rico by the junior author of this report. In addition to the data obtained from a study of the samples of fruit, notes are presented that give the facts concerning the location, discovery and propagation of each parent tree together with the description of some of the most important parent tree characteristics from data obtained largely by the junior author in the course of his official duties in Puerto Rico during the season of 1931.

The parent-tree selections have been given temporary names and numbers in order to identify them, the first one found being called Rico No. 1, the second Rico No. 2. and the other two Rico No. 5 and Rico No. 6. No fruits have been produced by the progeny trees as yet but their foliage indicates that the characteristics of the parent trees have been probably perpetuated through bud propagation.

Location and Characteristics of the Rico No. 1

This tree is located on the mountain coffee plantation owned by Don Francisco Martínez in the Mayagüez district of Puerto Rico at an elevation of about 1,200 feet above sea level. The soil on this plantation is red clay. The tree was discovered by A. D. Shamel on September 11, 1928, and the first progeny propagation was made on September 15, 1928, at Trujillo Alto in the nursery of the Plant Propagation Station. The nursery progeny was subsequently planted at the Propagation Station, the Insular Experiment Station, the various Model Farms and the Orchard of Hill Bros. at Sabana Llana. The young progeny tree had some fruit this year (1932) but the San Ciprián hurricane of September 26 (1932) shook them off; the trees, however, were not damaged. The parent tree is about forty years old, about 30 feet high, has a spread of about 30 feet, the diameter of the tree three feet from ground is about 12 inches. As the result of the hurricane of September 1928, the heavily laden tree was seriously injured and is now in very poor condition altho at the time of its discovery it was very vigorous. The habit of growth

of this parent tree is erect, the yield for 1932 was estimated at from 3 to 4 cases of oranges, the uniformity of the fruit is good and the commercial quality of the oranges is excellent. The tree is located on a shady mountain slope, one in a row of oranges that form a border for the adjacent coffee plantation.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 1

Individual Orange Number	Weight Ounces	Circumference Inches
1	11½	10 10/16
2	11½	10 7/16
3	11	10 7/16
4	10	9 13/16
5	9	9 11/16
6	8½	9 9/16
7	8	9 4/16
8	8	9 3/16
9	8	9 5/16
Average	9.5	9.81

The color of the rinds of the fruits is deep yellow with a reddish tinge, the texture is smooth; the shape of the fruit is slightly obovoid; the peel is about 3/16 of an inch thick, the flesh is firm, has a deep yellow color, exceptionally small amount of tender rag and excellent eating quality; the juice is abundant, 3 oranges producing about one pint; the color of the juice is yellow and more attractive than that of the other samples of Rico oranges examined, the flavor is excellent, eleven segments in one orange; small solid core; no seeds; no navel; soluble solid-acid ratio 11.8 to 1.

LOCATION AND CHARACTERISTICS OF THE RICO NO. 2

The parent tree RICO No. 2 was located by Julio S. Simons, Superintendent of the San Sebastián Demonstration Farm during 1930 on the mountain coffee plantation owned by Don Francisco Roig in Barrio Perchos between San Sebastián and Lares, about one and half hour on horse back from the highway. The tree is located about 2,000 feet above sea level. The soil is a heavy reddish clay. The first progeny propagation of this tree was made by A. Mayoral at the San Sebastián demonstration farm and at the Plant Propagation Station of Trujillo Alto on February 15, 1930, and another was made in June, 1931, by E. H. Twight. The resulting nursery progeny trees were planted subsequently at the Plant Propagation Station of Trujillo Alto and at the San Sebastián Model Farm.

This parent tree is about 40 years old, has a height of about 30 feet and a spread of about 30 feet. The diameter of the trunk three feet above the ground is about 12 inches. The vigor of vegetative

growth is good and the crop for 1932 is estimated to be from 3 to 4 cases. The fruit is fairly uniform with the exception of that on the central growth. The tree has an erect habit of growth. It is growing on a steep hillside and in partial shade.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 2*

Individual Orange Number	Weight Ounces	Circumference Inches
1	12	10 5/16
2	11	10 4/16
3	11	10 4/16
4	10	10 3/16
5	10	9 15/16
Average	10.8	10.23

* 3 oranges badly effected with brown rot decay, not included.

The color of the rinds is deep yellow tinged with red, the texture is smooth; the shape of fruit is obovoid; the peel is 3/16 of an inch in thickness; the flesh is firm, has a deep yellow color, tender rag and good eating qualities; the juice abundant, 3 oranges producing a little less than a pint of juice and has a fine distinctive flavor; the core is small and solid; 9 segments in one fruit; small rudimentary navels in rinds at blossom ends of the fruit with very small navel opening or practically closed; no seeds; soluble solid-acid ratio: 14.5 to 1.

Location and Characteristics of the Rico No. 5

This tree is located on the mountain coffee plantation owned by Don Ignacio Roig near Guayanilla in the southwestern part of the Island and about two hours by horseback from the highway (Kilometer 241) at an elevation of about 2,000 feet above sea level. The soil is a heavy clay loam. This parent tree was located by Félix A. Velasco, Agricultural Agent at Guayanilla, in the Fall of 1930. As in the case of the Rico No. 2 and of the Rico No. 6 parent trees, the owner had known for years that this particular tree was prolific and produced each year crops of commercially desirable and seedless oranges. Progeny propagation of this parent tree was first made during the Spring and Fall of 1931 at the Insular Station at Río Piedras and at the Plant Propagation Station at Trujillo Alto by the junior author, and again in 1932.

The parent tree is about 40 years old, about 30 feet high and has a spread of about twenty-five feet. The diameter of the trunk three feet above ground is ten inches. The vigor of vegetative growth is good and the yield of fruit is about 3 cases annually. The fruit is

uniformly good. The tree has an upright habit of growth but leans to the northwest on account of prevailing winds. It is located on a steep mountain slope and stands on a ledge that overhangs a dashing mountain stream.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 5

Individual Orange Number	Weight Ounces	Circumference Inches
1	15	11 14/16
2	14	11 10/16
3	13	11 6/16
4	13	11 1/16
5	12½	10 13/16
6	12	10 15/16
7	12	10 13/16
8	9	9 15/16
Average	12.5	11.06

The color of the rind is light yellow, the texture somewhat coarse; the shape of the fruit is slightly obovoid but more spherical than in the case with the other samples; the peel is about 4/16 inch thick; the flesh has a deep yellow color and the rag tender; the juice abundant and has a good color; 3 oranges produced one pint of juice; the core is open and about 10/16 inch in diameter; ten segments in one fruit; one large imperfect seed was found in 5 fruits; no navels; the soluble solid-acid ratio: 12.5 to 1.

Location and Characteristics of the Rico No. 6

The parent tree of the Rico No. 6 is located on the mountain coffee plantation owned by Don Carmelo Albino Bisot near Sabana Grande and about two hours by horse back from Sabana Grande. The soil is a heavy reddish clay with a shallow covering of black loam. The tree stands at an elevation of about 2,000 feet above sea level.

It was located by Félix A. Velasco, Agricultural Agent, Guayanilla, and was propagated at the Insular Experiment Station at Río Piedras in March, 1931. The resulting progeny trees were planted at the Plant Propagation Station at Trujillo Alto in April, 1932, by the junior author. The parent tree is about forty years old, thirty feet high and has a spread of about thirty feet. The trunk diameter three feet above ground is about 12 inches. The vigor of vegetative growth is good, the production fair and the fruits are fairly uniform. The habit of tree growth is erect and the tree is growing on a shady mountain slope. As with the other selected parent trees, Rico No. 1, Rico No. 2 and Rico No. 5, no pruning, cultivation, spraying, soil fertilization or other care has been given this tree.

DESCRIPTION OF SAMPLES OF RICO ORANGE No. 6

Individual Orange Number	Weight Ounces	Circumference Inches
1	11½	10 13/16
2	10	10 6/16
3	9½	9 12/16
4	9	9 11/16
5	9	9 7/16
6	9	9 7/16
7 Very flat	7½	9 6/16

The color of the rind of fruit is deep yellow tinged with red and the texture is smooth, the shape of the fruits is somewhat flattened as with the Marsh Grape fruit; the peel is about 4/16 of an inch thick; the flesh is deep yellow in color and has a tender rag; the juice is abundant and of exceptionally fine flavor, three and one-half oranges produced a pint of juice; 4 fruits had a total of four perfect and two imperfect seeds and two fruits were seedless; no navel; soluble solid-acid ratio: 12 to 1.

EXPLANATION OF PLATES

Plate VI. Typical fruits from seedless orange selection Rico No. 1. Original tree near Mayagüez, Puerto Rico.

Plate VII. Typical fruits from seedless navel orange selection Rico No. 2. Ranch of Mr. Roig, San Sebastián, Puerto Rico.

Plate VIII. Typical fruits from seedless orange selection Rico No. 5.

Plate IX. Typical fruits of seedless orange selection Rico No. 6. Sabana Grande.

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PLATE VI.

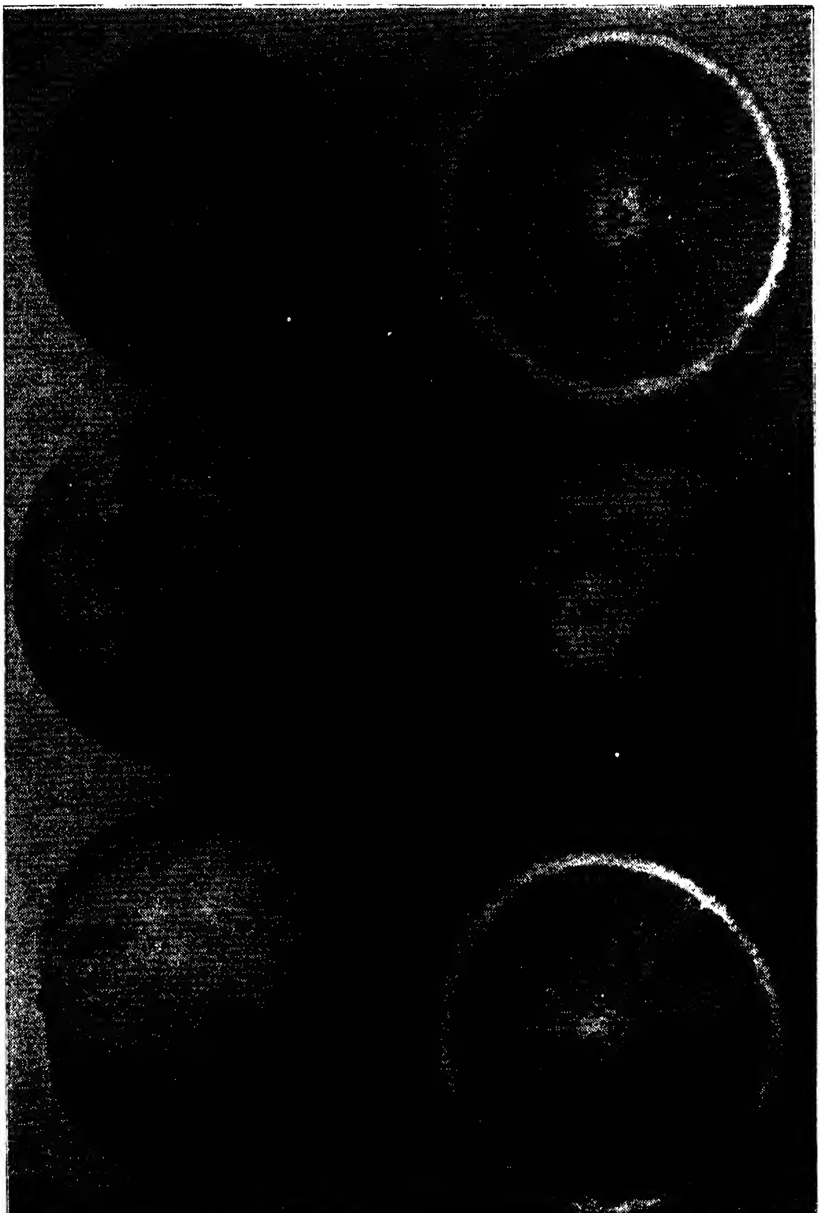


PLATE VII.

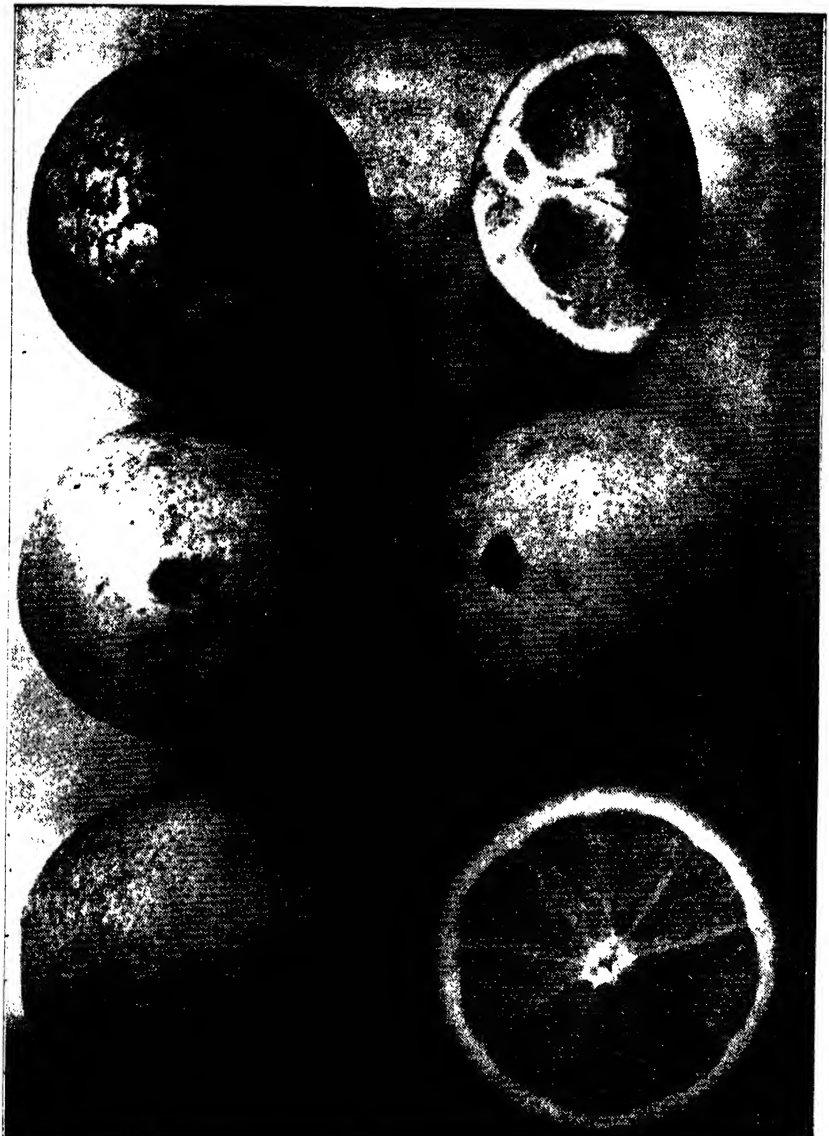


PLATE VIII.

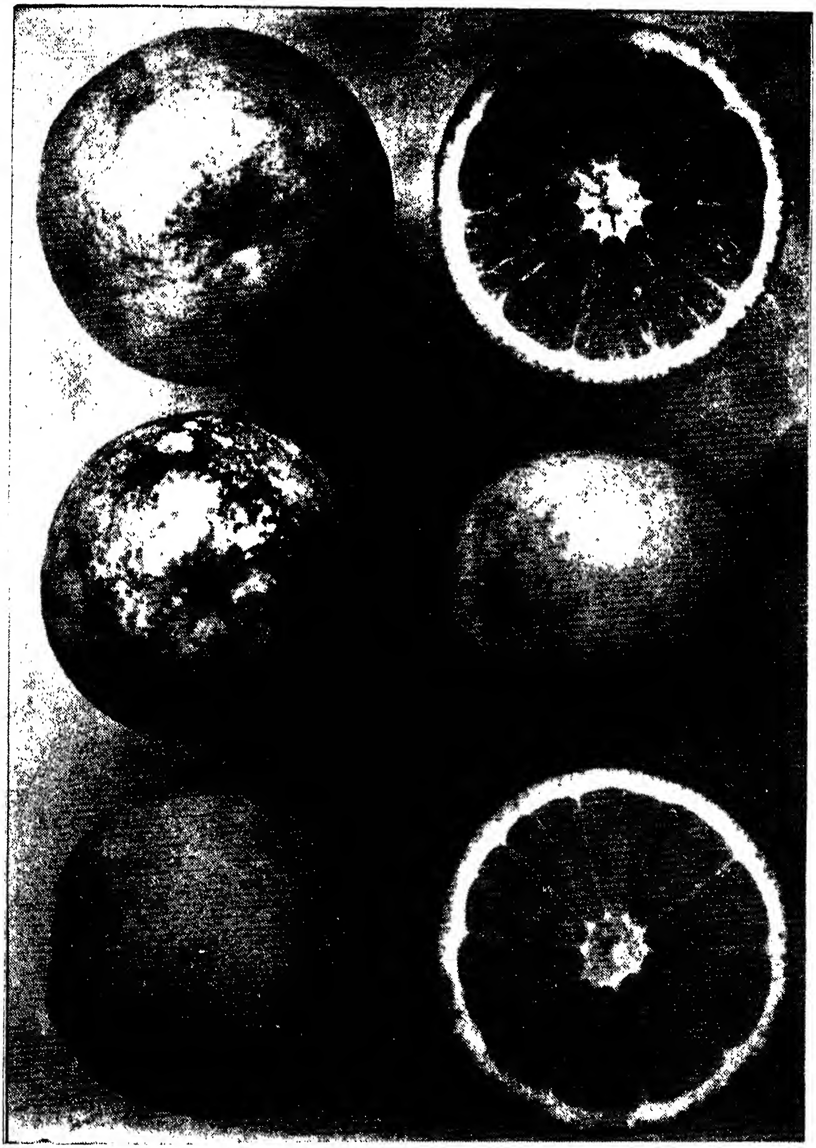
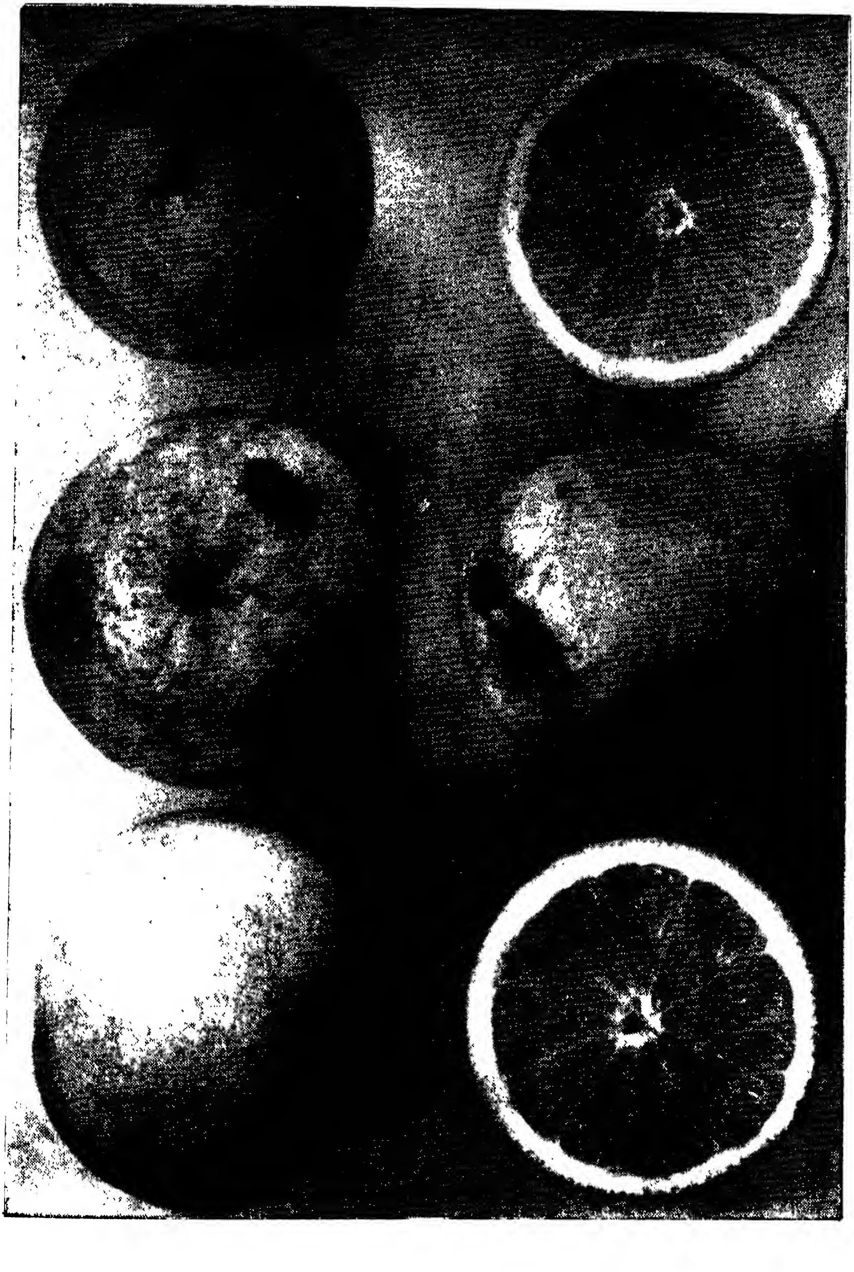


PLATE IX.



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ANASTREPHA (TRYPETYDAE, DIPTERA) FRUIT FLIES IN PUERTO RICO

By FRANCISCO SEÍN, JR., *Assistant Entomologist,*
Insular Experiment Station, Río Piedras, P. R.

Two species of fruit flies of the genus *Anastrepha* occur in the Island of Puerto Rico. In this region, they can be conveniently differentiated on the basis of the host selection, that is, the fruits in which the maggots are found, although in the case of two of the host fruits, both species may be found together. The two species can unquestionably be differentiated in the egg and adult stages. In the larval stage, the one character used to distinguish them seems to be constant. One is described as a distinct new species: *unipuncta*. The other, although differing greatly in host fruits from the species *fraterculus* as reported from some localities in South America, is here considered as a variety of that species: *mombinpraeoptans* because of its preference for the hog plum, (*Spondias mombin* L.). The lack of more data from South America does not seem to justify a greater differentiation at present.

What has previously been called the West Indian fruit fly, *Anastrepha fraterculus*, was described by Wiedemann (**10**) in 1830 from a Brazilian specimen and was first reported from Puerto Rico by Gundlach (**4**) in 1887 as *Acrotoxa fraterculus* and *Trypeta fraterculus* Wied., in synonymy as determined by Roeder. Up to recently it was considered the only species of *Anastrepha* on the Island.

In 1911, after the Puerto Rico Experiment Station at Mayagüez had introduced some of the selected East Indian varieties of mangoes it was noticed that some, especially the Cambodiana, were attacked by fruit flies, and in that same year, Tower (**9**) published an account of the life history of the insect under the name of *Anastrepha acidusa* Walker, as determined by W. R. Walton.

In 1912, Dr. Hooker (**5**) also of the Puerto Rico Station reported that a comparison made by Dr. L. O. Howard with the type of *A. acidusa* in the British Museum showed the fruit fly from Puerto Rico (it is not possible to tell which of the two) to be a different species, possibly undescribed. In the same report, however, it is added that

Prof. Bezzi identified specimens as *A. fraterculus* and that Mr. Knab was inclined also to consider them as belonging to that species.

In Dr. Wolcott's check list of the insects of Puerto Rico (**11**) published in 1923, *A. fraterculus* is the only species recorded, and *A. acidusa* is given as a synonym. The host plants of the two species are given as those of the single species recognized at the time.

In 1925, at a hearing (**7**) held in Washington, D. C., to consider prohibiting or restricting the entrance of citrus fruits from Puerto Rico into the United States due to the presence of *A. fraterculus,* Dr. C. L. Marlatt expressed the opinion that although *A. fraterculus* did not infest citrus fruits in Puerto Rico, *Anastrepha* larvae had been found on one occasion in citrus from the Isle of Pines and furthermore stated that:

"In our examination of citrus fruits from the West Indies and Mexico, Central America, etc., we find that these native fruit flies which occur throughout all that region do not attack citrus. It is not at all impossible that there may be a rare case of a maggot of these other fruit flies coming in citrus fruit. The insect may lay eggs under some abnormal conditions in citrus fruit and there is a possibility of course that infestation may result."

Since this hearing, the exportation of citrus fruits from Puerto Rico into the United States has continued uninterruptedly, the shipments being accompanied by permits issued by Inspectors of the Bureau of Plant Quarantine stationed on the Island. The permits are based on inspections made throughout the year in the groves and again in the packing houses before shipment. The inspections are most carefully conducted during the spring and summer and since 1931, with special care in the localities where infestations might be considered more likely to occur. As stated by Dr. G. G. Becker in the report on his trip of inspection to Puerto Rico, May 28 to June 13, 1931:

"A much greater fruit-fly risk is assumed in shipments of Cuban and Isle of Pines citrus than is assumed with Puerto Rican citrus because of the fact that fruit from the former Islands is given only a cursory examination on arrival."

In April, 1926, Mr. José Luciano of the Insular Quarantine Service found one fruit-fly larva in a native sweet orange (grown most likely in the western part of the Island) which was identified by Mr. C. T. Greene as *Anastrepha* sp. In the spring and summer of 1931 some infested grapefruit, sour oranges and one native sweet orange were found in the western part of the Island and a few infested Valencia oranges in two trees in a large commercial grove in the northern

part. In April 15, 1932, a few infested grapefruits and some sour oranges (very remarkably in the same grove and practically on the same date as the previous year), were again found in the west and a few infested sour oranges were also found in one locality in the south. Those infestations, as shown by careful surveys conducted by inspectors of the Bureau of Plant Quarantine and the Insular Quarantine Service in cooperation, have all been localized, of short duration and involving only an infinitesimal number of fruits compared with the total crop of the Island. Nothing can be added at present to the statements made by Dr. Marlatt to explain why those infestations take place. They do not occur when the flies are more abundant and neither do they seem to be caused simply by a lack or scarcity of their ordinary host fruits. They might possibly be due to a special activity of some of the flies in the spring and summer, or to a certain tendency of some individuals. Whatever the cause, and even though the host plants of the insect occur in the neighborhood of practically all the citrus groves in the Island without infestation taking place, the elimination of those host plants would eliminate the source of flies in the vicinity of the groves and therefore also the danger of infestation. Picking the fruit early would also reduce the danger since the infestations have been found in the spring and at the beginning of summer. The fly that has been reared from citrus fruits in Puerto Rico is *not* the one that breeds in mango, ''jobo'', and ''ciruela'' but another distinct species which breeds commonly in guava, rose apple, to some extent in tropical almond and less commonly in custard apple, star apple, zapodilla, beach plum and kunquat.

So much confusion exists as to what are the characters of *Anastrepha fraterculus* Wied., that it would seem desirable to describe what has been considered to be that species in Puerto Rico as new. But due to lack of sufficient reared material and data on the immature stages from a large number of localities throughout its wide range in the West Indies, Central and South America, for the present, the insect as found in Puerto Rico is here redescribed as a variety within the species *fraterculus*. Several such varieties may eventually be established and some may prove to be distinct species. The creation of varietal names will facilitate the study of the genus *Anastrepha* and particularly the species *fraterculus*. It may be useful also in connection with quarantine regulations. A long list of plants has been reported infested by *A. fraterculus,* but in some localities where *A. fraterculus* is reported to occur, some of those plants are not infested. Manifestedly, one locality should not be put under

quarantine regulations on the basis of the plants the insect attacks in another. The reason why some plants are infested in one locality and not in another may most readily be explained perhaps, by the existence of varieties within the species *fraterculus*. It is possible also that in some localities, plants reported infested by *A. fraterculus* may have been infested, as in Puerto Rico, by some other closely related species heretofore confused with it.

On this basis it would appear desirable to retain the common name of West Indian fruit fly, restricting it to the mango and jobo infesting variety: *mombinpraeoptans*, which does not attack citrus in Puerto Rico. This variety is probably found in other West Indian islands besides Puerto Rico, and presumably also in tropical Central and South America. For the variety (if we may consider it as such) of *A. fraterculus* which attacks citrus and subtropical fruits in Brazil, Argentina and other South American countries, the common name of South American fruit fly as used by Essig (**2**) would be appropriate. Essig, when using that term in his book, was not considering varieties.

In describing the adult, the three bands on the wings (Fig. 60) are given names. The basal band extends from the base of the wing along the costal border to the end of the apical cell. The S-shaped band is clearly marked from the tip of the wing along the anterior margin to about the middle, thence bending over the radio-medial cross-vein it reaches the tip of the anal cell diffusing over it towards the base of the wing. The two arms of the inverted V-band rest on the posterior margin. Because there is no connection between them, the basal and the S-shaped bands stand out very clearly in figures 2 and 60. In figure 3 (*A. fraterculus* from Argentine), there being no connection between the S-band and the inverted V-band, the shape of the latter is quite striking. In describing wings such as shown in figures 2 and 3, the three bands immediately catch the eye. In figure 1, however, because of the connections, the three-banded effect is somewhat lost. Although *A. fraterculus* in Argentine is not discussed in detail in this paper, an illustration of the wing has been introduced for comparison.

In obtaining the eggs of the two species, it has been found convenient to take advantage of the fact that the females when kept for a time in cages without fruits in which to oviposit, seem to be in such a hurry when suitable fruits are made available, that they deposit the first eggs on the surface of the fruits as they run over them trailing the ovipositor. The normal shape and size of the eggs can be more easily observed in such than in eggs dissected out of

the flies or out of the fruits. In the variety *mombinpraeoptans* the tips of the eggs protruding out of the cuticle of the fruits makes the search for them a simple operation, but unless the spot where the females insert the ovipositor in fruits in cages is marked, it is quite difficult to locate those of *A. unipuncta*, which are deposited entirely under the cuticle.

Wiedemann's Description of **A. frateculus**

"Flavus; alis dimidio basilari costae, plaga S formi, fascia dimidia lineaque apicis obliqua flavis. Yellow, wing with basal half of rib yellow, "S" formed mark, half a hyphen and line at apex.

"Length 2⅔ lines. From Brazil.

"This species is much similar to *D. parallelus*, only it is much smaller, the costal stripe and the band and the line, which correspond to the third stripe of that one, are different. Antennae medium length, bristle not plumose. Color very pale rust yellowish; face the same, frons somewhat deeper yellow. Entire back (thorax) of a pale yellow in between acorn-brown to 'Izabell yellow',—this perhaps lost of its purity through smears with arsenic solution. Abdomen fuller yellow, sides of thorax and legs leather-yellow. Abdomen incisions (posterior edge of segments whitish. Bristles and hair of head and body black. Base of wing from the costa to the third longitudinal vein deep yellow, in the radial cell lighter. From the inner hind margin, near the base of the wing, an oblique "S" mark runs over the middle cross-vein with its first bend reaching the costa, (whereby there is left a triangular hyaline space between it and the basal stripe), then with a sharp bending along the outer wing margin to below the end of the third longitudinal vein. From the hind edge of the wing there is a hyphen (band) spreading over the ordinary cross-vein and reaching to about the middle of the wing width; from the hind margin of the wing apex a tapering line extends obliquely and reaches over the end of the band, but in no way connected with the same. Band and line are slightly brown. In my collection."

Anastrepha frateculus Wied., var. **mombinpraeoptans,** new variety.

The adult: Maximum size, male 7 mm., female (Fig. 4) with ovipositor, 8 mm., ovipositor, 1.8 mm. Wing expanse, 14 to 15 mm.(1) Head yellow, face light lemon yellow, front a grayish yellow amber. Compound eyes metallic irridescent. An almost black bloch between the simple eyes. Antennae with slight reddish tinge, arista chestnut. Proboscis golden yellow, palpi with very slight reddish tinge. Thorax dorsally reddish brown (2) with dark chestnut or blackish pile (3);

(1) In Wiedemann's description the size is given as 2⅔ lines. In Pierce's manual it is 12 mm., exclusive of the ovipositor with a wing expanse slightly over 25 mm. In Argentina according to Rust (8) average sizes are for the male 7 to 8 mm., with a wing expanse of 15 to 16 mm., and for the female 10 to 11 mm., with the ovipositor, ovipositor 2 mm. and wing expanse 18 to 20 mm.

(2) According to Wiedemann: "the entire back (thorax) is of a pale yellow in between acorn-brown and Isabell-yellow, this perhaps lost of its purity through smears with arsenic solution."

median mesoscutal vitta sulphur yellow with whitish pile([3]), linear from collar expanding posteriorly into a cuneiform shape not reaching scutellum (Fig. 37); scutellum and lateral mesoscutal vitta sulphur yellow with scanty blackish pile. Metanotum a reddish amber with or without two markings which may be light or dark, shaped as spots or larger blotches Side of thorax dull yellow, pleural vitta enamelled sulphur yellow. An almost black rounded spot behind the wing base([4]). The usual bristles all black. Abdomen amber with blackish pile and black bristles, posterior edges of segments usually showing as three lighter transverse bands. Ovipositor reddish amber, darker than abdomen, dorsally with an almost black spot near the tip. Two rounded, almost black spots on the membrane at the base of the ovopositor([4]).

Legs lighter yellow than body, tibiae and tarsi, slightly tinged with reddish.

Wings (Fig. 1) hyaline, iridescent, markings in the shape of three brownish orange bands overlaid in part with a smoky brown which in places is blackish. The borders of the bands darker in places. Occasional vacuoles or lightly pigmented areas in the bands. Basal band brownish orange from the base of the wing to apical cell. Apical cell darker. S-shaped band dark smoky from tip of wing along anterior margin to about the middle, thence dark brownish orange over the radiomedial cross-vein and lighter brownish orange over it into cell 1st M_2. On cell Cu_1 there are usually two dark spots, sometimes coalescing, one of which is on the tip of the anal cell([5]). The basal and the S bands are connected at a point near the r-m cross-vein thus leaving a triangular or notch shaped hyaline area between them with its base on the anterior margin and the apex pointing towards the posterior margin of the wing. Inverted V band with its arms resting on the posterior margin, the vertex connecting with the S band, the connection usually strong([6]), the vertex is brownish orange, the arms smoky. Very exceptionally (Fig. 55) the arms of the inverted V band may be disconnected as described by Wiedemann. In one specimen the S band was found to be cut in two at the middle, (Fig. 56). Figures 43 to 56 show some only of the more striking variations that occur in the *mombinpraeoptans* variety.

Described from 3,000 freshly killed specimens reared by the writer from the different fruits in which the insect breeds in Puerto Rico during the years 1927 to 1933 from many localities both in the costal plain and the higher elevations. Dried specimens in the collections of the Insular and Puerto Rico Experiment Stations and in the National Museum in Washington, D. C., some of them collected as far back as 1913 and identified as *A. fraterculus* have also been examined. Dried specimens are brownish with the vittae whitish.

Type.—A single female; (P. R. Ac. No. 44–33), March 20, 1933, Río Piedras, Puerto Rico; reared by F. Seín, Jr., from *Spondias mombin* L. In the U. S. National Museum, Washington, D. C.

Paratypes.—Four female specimens; (P. R. Ac. No. 44–33), March 20, 1933,

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([3]) In Wiedemann's description the bristles and hairs of head and body are black, but according to Loew (6) the pile on Wiedemann's type was light chestnut or yellowish. Dr. C. H. Curran has informed the writer that *fraterculus* has the abdomen wholly yellow haired and has yellow or brownish bristles.

([4]) Not mentioned in former descriptions of *fraterculus*.

([5]) According to Bezzi (1) this spot is not present in *fraterculus*. Greene (3) who states that the adults are easily differentiated on wing pattern illustrates the spot for *A. fraterculus* but not for *A. ludens* or *A. serpentina* and indistinct for *A. striata*.

([6]) In Wiedemann's description the arms are "in no way connected". Loew states that in Wiedemann's type the connection was present though not very distinct.

Río Piedras, Puerto Rico, reared by F. Seín, Jr., from *Spondias mombin* L. In the British Museum, London, England, and at the Insular Experiment Station, Río Piedras, Puerto Rico.

Mounted wings from which the drawings of the variations in pattern and slides from which the drawings of the posterior spiracles and the hairs or rays were made deposited at the Insular Experiment Station.

The egg: Length, 1.4 mm.; Width, 0.4 mm.; Spindle shaped with one end prolonged into a neck which usually swells somewhat into an ovoid head at its extremity, the other end bluntly pointed, (Figs. 8, 9 and 10). Egg membrane white, opaque, smooth and glossy. The egg is inserted in the fruit up to the shoulder, the head and neck protruding outside of the cuticle (Figs. 6–8 and 10). The larva emerges through a slit near the pointed end.

Described from eggs dissected out of fruits, from mature eggs dissected out of the female flies and from eggs deposited on the surface of fruits in cages.

The larva: Maximum length, 10 mm., width, 2 mm., at posterior end; cylindrical, tapering slightly towards cephalic end. When young, cream colored, usually turning later to a golden yellow. In addition to the head region, the body consists of 11 segments of about equal length; a ventral fusiform area on anterior portion of each of segments 2 or 3 to 11(7), (Fig. 16). Head, (Fig. 14), small, partly retractile, each side of the front bearing two broadly rounded somewhat flattened tubercles, the antennae(8) slightly larger; mouth hooks (Figs. 20–25), medium sized, first part rather slender, first and second parts black, second part shaped more frequently like the head of a hammer(9), third part with a dark brown infuscated area at base which fades to hyaline towards apices. Anterior spiracles small, yellowish, chitinized, with from 10 to 16 small rounded tubules(10) arranged in an irregular row, (Fig. 15). Posterior spiracles, (Figs. 17, 19 and 27), medium sized, each spiracle with three broad yellow entrances, each with a dark brown peritreme, entrances more frequently arranged so that the two above are parallel and the one below obliquely upturned(11), Figs. 17 and 19), but in some specimens all three entrances may converge, (Fig. 27). In some specimens the entrances may be described as short and thick, in others as longer and more slender. Hairs (rays) branched and well spaced as shown in (Fig. 17). Button large but indistinct. Above each spiracle two small tubercles in a transverse line and below, two small tubercles slightly wider apart and almost in a transverse line (12), (Fig. 26). The lower pair of tubercles is in some specimens located in a ridge, (Fig. 26, *a* and *b*), in others in two ridges (Fig. 26, *c* and *d*), and the innermost of the two tubercles is usually bifid (Fig. 26, *a* and *c*). Another pair of tubercles can usually be seen on the median line between the upper and the lower pair(14). Anal elevation large, rounded and with two prominent lobes.

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(7) According to Greene (3) in *A. fraterculus* the fusiform area occurs on segments 4 to 11.

(8) Greene illustrates a somewhat differently shaped antenna.

(9) Greene's illustration shows it shaped somewhat like a bottle.

(10) According to Greene *A. fraterculus* has from 15 to 17 tubules, *A. striata* and *A. serpentina* go as high as 17 and *C. capitata* as low as 10.

(11) According to Greene the second is the only arrangement that occurs in *fraterculus*.

(12) According to Greene there is one tubercule below each spiracle.

(13) Greene does not consider them as bifid; this condition was first pointed out to the writer by Mr. F. H. Benjamin.

(14) Not mentioned by Greene.

. Described from 500 full grown larvae from the same sources as the adults.

The puparium: Maximum length, 5.7 mm., width, 2 to 2.4 mm., cylindrical, yellowish, later turning to mahogany; 11 distinct segments, (Figs. 32–35). Anterior spiracles like those of the larva but darker and somewhat shrunk. Posterior spiracles (Fig. 36) medium sized, dark reddish, located in a faintly depressed area somewhat oval in shape, a broad flattened projection extending down between the upper end of the spiracular plates([15]), each spiracle with three broad yellow entrances, each located on a well defined ridge; button small and indistinct. Anal plate large, dark and round.

Described from 500 specimens from the same source as the larva. Material from Panama (whence Greene drew his description) has also been examined.

Hosts: Hog plum, "jobo" *Spondias mombin* L.; "ciruela", *S. cirouella* Tussac and *S. purpurea* L., some mango varieties, *Mangifera indica* L., and rarely in "jobo de la India", *S. dulcis* Frost. Occasionally some may breed in guava, "guayaba", *Psidium guajava* L., and rose apple, "pomarrosa", *Jambos jambos* L.

Anastrepha unipuncta new species

The adults of this species can readily be differentiated from *A. fraterculus* Wied., var. *mombinpraeoptans* by the dark spot on the suture between the metathorax and the scutellum. The egg has no neck and is deposited entirely underneath the cuticle of the fruit. The larva has the hairs or rays in the posterior spiracles more numerous, closer together and somewhat less branched. No character has yet been found to distinguish the puparium. An occasional puparium may be formed inside the fruits in which the larvae have developed, a habit which has not been observed in *A. fraterculus* Wied., var. *mombinpraeoptans*.

The adult: Slightly darker than *A. fraterculus* Wied., var. *mombinpraeoptans* and similar in size; ovipositor very slightly longer and wider at the middle, (Fig. 42). Thorax (Fig. 5) dorsally a reddish amber or honey color the median mesoscutal vitta linear and faintly lighter than thorax; lateral and pleural vittae a dull greenish yellow. Pile on dorsal part of thorax all blackish (Fig. 38). A noticeable dark spot on the suture between the metathorax and the scutellum, (Figs. 5, 38 and 39) invariably present. Wing markings (Figs. 2 and 57–60), usually darker and more smoky and in some individuals different in pattern from *A. fraterculus* Wied., var. *mombinpraeoptans*. Basal band dark smoky. S shaped band dark smoky to near the r-m cross vein thence brownish yellow to cell Cu_1. In cell Cu_1 the two dark smoky spots frequently coalesce extending towards the base of the wing. When the basal and the S bands are not connected, the hyaline area between the two bands extends uninterruptedly towards the base of the wing, (Figs. 2 and 60). The connection between the S and the inverted V bands though strong in some individuals (Figs. 2 and 58) may be weak (Figs. 57 and 60) or lacking in others (Fig. 59). In many individuals

([15]) According to Greene the area is hexagonal and the flattened projection is not present, it being specific for *A. striata*.

there are two slightly lighter areas in the basal band on either side of the humeral cross vein. In dried or in specimens preserved in alcohol the spot on the dorsum is always visible.

Described from over 500 specimens reared from the different fruits in which the insect breeds collected in different localities in Puerto Rico including the lower and the higher elevations. Specimens in the collection of the Insular Experiment Station, P. R., reared from guava in 1913 and identified as *A. fraterculus* Wied., have also been studied.

Type.—A single female; (P. R. Ac. No. 45–33), March 20, 1933, Río Piedras, Puerto Rico; reared by F. Seín, Jr., from *Psidium guajava* L. In the U. S. National Museum, Washington, D. C.

Paratypes.—Four female specimens; (P. R. Ac. No. 45–33), March 20, 1933, Río Piedras, Puerto Rico, reared by F. Seín, Jr., from *Psidium guajava* L. In the British Museum, London, England, and at the Insular Experiment Station, Río Piedras, Puerto Rico.

Mounted wings from which the drawings of the variations in pattern, and slides from which the drawings of the posterior spiracles and the hairs or rays were made deposited at the Insular Experiment Station.

The egg: Length, 1 mm., width, 0.3 mm. Spindle shaped, both ends bluntly pointed and one with reticulations which may be indistinct in some cases, (Figs. 11–13). Egg membrane opaque, smooth and glossy. Egg inserted in the fruit just underneath the cuticle, the reticulated end nearest to the cuticle.

Described from mature eggs dissected out of the female flies and from eggs laid in and on fruits in cages in the laboratory.

The larva: Similar in size and color and other characters to that of *A. fraterculus* Wied., var. *mombinpraeoptans* except that the bunches of hairs (rays) in the posterior spiracles are more numerous, closer together and not so branched, (Fig. 18), entrances more frequently convergent; number of tubules in anterior spiracles from 9 to 17, the lowest numbers have been found in rose apple and citrus and the highest also in citrus.

Described from 200 full grown larvae from the same source as the adults.

The puparium: Similar to that of *A. fraterculus* Wied., var. *mombinpraeoptans*. An occasional one may be formed inside the fruits in which the larvae have developed, a habit *A. fraterculus* Wied., var. *mombinpraeoptans* has not been observed to have.

Described from over 200 specimens from the same source as the larva.

Hosts: Guava "guayaba", *Psidum guajava* L.; rose apple, "pomarrosa", *Jambos jambos* L.; tropical almond, "almendra" *Terminalia catappa* L.; kunquat, *Fortunella margarita* (Champ) Swingle; star apple, "caimito", *Chysophyllum cainito* L.; zapodilla, "níspero", *Sapota achras* Mill.; custard apple or bullock's heart, "corazón", *Anona reticulata* L.; and beach plum, "hicaco", *Chrysobalanus icaco* L., occasionally, in the spring and early summer sporadically a few may breed in grapefruit, *Citrus maxima* Merril; sour orange, "naranja agria", *C. aurantium* L.; native and Valencia oranges, "chinas", *C. sinensis* L.

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BIBLIOGRAPHY

1. **Bezzi, M.** Una Nuova Specie Brasiliana del genere Anastrepha (Dipt.). *In* Bollettino del Laboratorio di Zoologia generale e agraria della R. Scuola Superiore d'Agricoltura, Portici. **13**: 3–14. 1919.

2. **Essig, E. O.** Insects of Western North America, pp. 1035, fig. 766. The Macmillan Co., New York, 1926. (See p. 600.)

3. **Greene, C. T.** Characters of the Larvae and Pupae of Certain Fruit Flies. *In* Jour. Agr. Res. **38**(9): 489–504, illus. 1927.

4. **Gundlach, J.** Apuntes para la Fauna Puertorriqueña. *In* An. Soc. Esp. Hist. Nat. **20**, 109–207, 323–381. Madrid, 1891.

5. **Hooker, C. W.** Report of the Entomologist. *In* Ann. Rept. Porto Rico Agr. Expt. Sta. **1912**: 34–36. Washington, D. C. July 26, 1913.

6. **Loew, H.** and **Osten Sacken.** Monographs of the Diptera of North America, Part. **3**, Smithsonian Miscelaneous Collections. **256**: 351 + XIII pl. 4. Washington, Dec. 1873. (See pp. 222–223.)

7. **Marlatt, C. L.** *In* Report of public hearing to consider the advisability of restricting or prohibiting the entry from Porto Rico of fruits and vegetables in the raw or unmanufactured state on account of the West Indian fruit fly, the bean pod borer, and other injurious insects. Jour. Dept. Agr. P. R. **8**(1): 25. (1924) 1925.

8. **Rust, E. W.** La mosca de la fruta. *In* Rev. Ind. Agric. Tucumán, Argentina. **9**(3–4): 33–42. 1918. Also *In* Jour. Ec. Ent. **11**: 457–467.

9. Tower, W. V. Report of the Entomologist. *In* Ann. Rept. P. R. Agr. Expt. Sta. **1911**: 32–36. Washington, D. C. Sept. 3, 1912.

10. Wiedemann, C. R. W. Aussereuropaische zweifluegelige Insekten, **2**: 384, pl. 5. Hamm. 1830. (See pp. 524–525. (Dacus).

11. Wolcott, G. N. Insectae Portoricensis. Jour. Dept. Agr. P. R. **7**(1): 229. (1923) 1924.

Plate X

Fig. 1.—*Anastrepha fraterculus* Wied., var. *mombinprœeoptans,* right wing, greatly magnified.

Fig. 2.—*Anastrepha unipuncta* n. sp. right wing, same magnification as fig. 1; notice that the bands are darker and that the basal and the S shaped band are disconnected.

Fig. 3.—*Anastrepha fraterculus* Wied., from Argentina, right wing, same magnification as figs. 1 and 2; notice that the wing is larger than the other two, that the S shaped band and the inverted V bands are more slender and that they are disconnected; in color the Argentinean is similar to the *mombinpraeoptans* variety and both are lighter than *A. unipuncta.*

Fig. 4.—*Anastrepha fraterculus* Wied., var. *mombinpraeoptans,* dorsal view of female adult greatly magnified; notice the three bright longitudinal sulphur yellow stripes on the thorax.

Fig. 5.—*Anstrepha unipuncta* n. sp., dorsal view of thorax, magnification about the same as in fig. 4; notice the dark spot on the suture between the metathorax and the scutellum not present in fig. 4 and that the longitudinal stripes are dull and indistinct.

Fig. 6.—*Anastrepha fraterculus* Wied., var., *mombinpraeoptans,* the end of the egg protruding out of the cuticle of a green fruit, greatly magnified.

Fig. 7.—Same, the end of the egg protruding out of a ripe fruit.

Fig. 8.—Section of a green hog plum, *Spondias mombin* L., to show the egg as it is inserted by the female. In other fruits the egg is inserted in the same manner.

Plate XI

Fig. 9.—*Anastrepha fraterculus* Wied., var. *mombinpraeoptans,* longitudinal section of egg, greatly magnified.

Fig. 10.—Same lateral view of egg with fruit tissues adhering to it as it usually appears when dissected out of fruits, not so greatly enlarged as Fig. 9.

Fig. 11.—*Anastrepha unipuncta,* n. sp., lateral view of egg showing reticulations at one end, magnification slightly more than Fig. 10 and very much less than Fig. 9.

Fig. 12.—Same, showing slight difference in shape and size.

Fig. 13.—Same, showing some variation in shape and reticulations indistinct.

Fig. 14.—*A. fraterculus* Wied., var., *mombinpraeoptans,* lateral view of head of larva showing: Mth, mouth; Oh, oral hook; a, antenna, ASp, anterior spiracle, greatly magnified.

Fig. 15.—Same, anterior spiracle of mature larva, lateral view, greatly magnified.

Fig. 16.—Same, lateral view of mature larva showing, VFa, ventral fusiform area, and 1 to 11, number of segments, greatly magnified.

Fig. 17.—Same, posterior spiracles of mature larva showing the hairs or rays well spaced and branched and the two entrances above parallel with the lower one obliquely upturned, greatly magnified.

Fig. 18.—*Anastrepha unipuncta,* n. sp. posterior spiracles of the female showing the hairs or rays more abundant, closer together and less branched than in Fig. 17, greatly magnified, entrances convergent.

Fig. 19.—*Anastrepha fraterculus* Wied., var., *mombinpraeoptans,* posterior spiracles of one third grown larva showing the two spiracular plates closer together than in the full grown larva in Fig. 17, but the hairs or rays about the same, greatly magnified.

Fig. 20.—Same, mouth hooks of the full grown larva, lateral view showing the three parts, greatly magnified.

Figs. 21–25.—Same, mouth hooks of full grown larva, first and second parts of different individuals showing variations in the shape, greatly magnified.

Fig. 26.—Same, posterior end of full grown larva showing the tubercles: a and b, in profile, located in one ridge; c and d, in profile, located in two ridges; a and c, in profile, with inner tubercles bifid, greatly magnified.

Fig. 27.—Same, posterior spiracles of the mature larva showing the entrances convergent, hairs or rays not shown, greatly magnified.

Figs. 28–31.—*Anastrepha unipuncta* n. sp., posterior spiracles of the mature larva showing the two upper entrances horizontal and the lower one obliquely upturned, hairs or rays not shown, greatly magnified.

Plate XII

Fig. 32.—*Anastrepha fraterculus* Wied., var., *mombinpraeoptans*, lateral view of puparium showing: PSp, posterior spiracles; An, anus; Sp, lateral spiracle; P, vertical cleavage line; O, horizontal cleavage line; ASp, anterior spiracle; 1 to 11, number of segments, greatly magnified.

Fig. 33.—Same, lateral view of opened puparium after the emergence of the fly, ASp, anterior spiracle, greatly magnified.

Fig. 34.—Same, dorsal view of puparium showing: Asp, anterior spiracle; Mth, mouth; PSp, posterior spiracle, greatly magnified.

Fig. 35.—Same, ventral view of puparium showing AnP, the anal plate, greatly magnified.

Fig. 36.—Same, posterior spiracles of the puparium showing the broad flattened projection extending down between the upper end of the spiracular plates, greatly magnified.

Fig. 37.—Same, dorsal view of thorax showing the distribution of the dark colored pile, the whitish pile on the median mesoscutal vitta not showing, greatly magnified.

Fig. 38.—*Anastrepha unipuncta*, n. sp., dorsal view of thorax showing the distribution of the dark colored pile and the spot on the suture between the metathorax and the scutellum, greatly magnified.

Fig. 39.—Same, a variation in the shape of the spot between the metathorax and the scutellum, greatly magnified.

Fig. 40.—*Anastrepha fraterculus* Wied., var. *mombinpraeoptans*, external genitalia of the male showing the claspers, greatly magnified. The external genitalia of *A. unipuncta* show identical characters.

Fig. 41.—Same, lateral view of the ovipositor, greatly magnified.

Fig. 42.—*Anastrepha unipuncta*, n. sp., lateral view of the ovipositor, same magnification as Fig. 41; notice the difference in shape and size, Fig. 42 being wider at the middle and slightly longer than Fig. 41.

Plate XIII

Figs. 43 to 51.—*Anastrepha fraterculus* Wied., var. *mombinpraeoptans*, right wing of individuals showing variations in pattern, somewhat diagrammatic, greatly magnified.

Fig. 43.—Showing the connection between the S and the inverted V bands very weak.

Fig. 44.—The S band widening downwards and the inverted V band widening at the apex to make a wide connection.

Fig. 45.—The S and the inverted V bands connected at two points.

Fig. 46.—A wide connection between the S and the inverted V bands and the two arms of the inverted V band connected along the posterior margin of the wing.

Fig. 47.—Same, but the connection between the two bands still greater.

Fig. 48.—Same, but the arms of the inverted V band disconnected along the posterior margin of the wing.

Fig. 49.—The S and the inverted V bands connected at two points and the arms of the inverted V band connected along the posterior margin of the wing.

Fig. 50.—Same, but the arms of the inverted V band not connected along the posterior margin of the wing.

Fig. 51.—Same, the S and the inverted V bands almost connected near the tip of the wing in a striking manner.

Plate XIV

Figs. 52 to 56.—*Anastrepha fraterculus* Wied., var. *mombinpraeoptans,* right wing of individuals showing variations in pattern, greatly magnified, somewhat diagrammatic.

Fig. 52.—A very wide connection between the S and the inverted V bands and a striking curve of the outer arm of the inverted V band.

Fig. 53 and 54.—Breaking up of the S and the inverted V bands by vacuoles.

Fig. 55.—The two arms of the inverted V band disconnected somewhat as described for *A. fraterculus* by Wiedemann in Brazil.

Fig. 56.—The two halves of the S band disconnected, a most unusual condition.

Figs. 57–60.—*Anastrepha unipuncta* n. sp., right wing of individuals showing variations in pattern, greatly magnified, somewhat diagrammatic.

Figs. 57 & 58.—A pattern similar to that of *A. fraterculus* Wied., var. *mombinpraeoptans,* (Fig. 1) differing from it only in being darker.

Fig. 59.—The S and the inverted V bands entirely disconnnected, a condition seldom if ever occurring in *A. fraterculus* Wied., var. *mombinpraeoptans.*

Fig. 60.—The basal and the S bands entirely disconnected, a condition not observed in *A. fraterculus* Wied., var., *mombinpraeoptans.*

PLATE X.

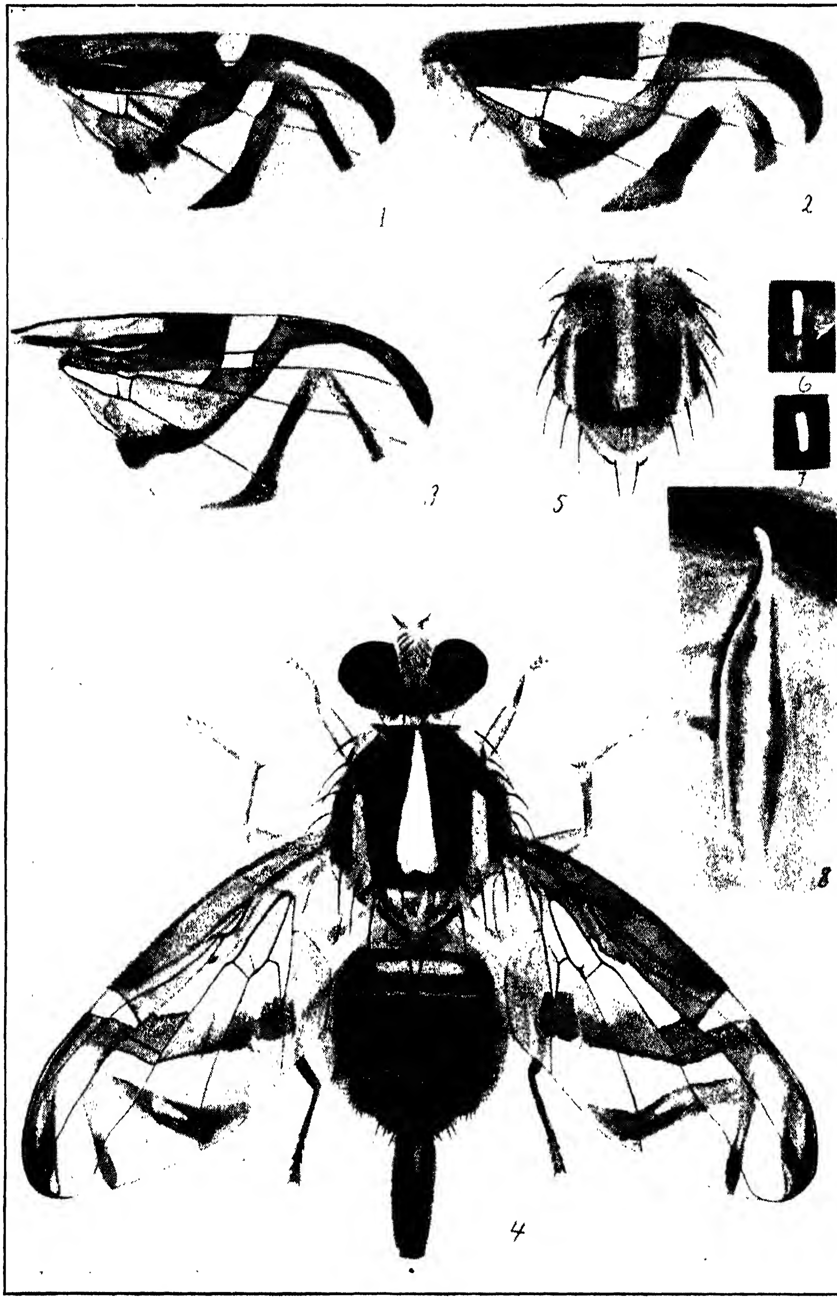

PLATE XI.

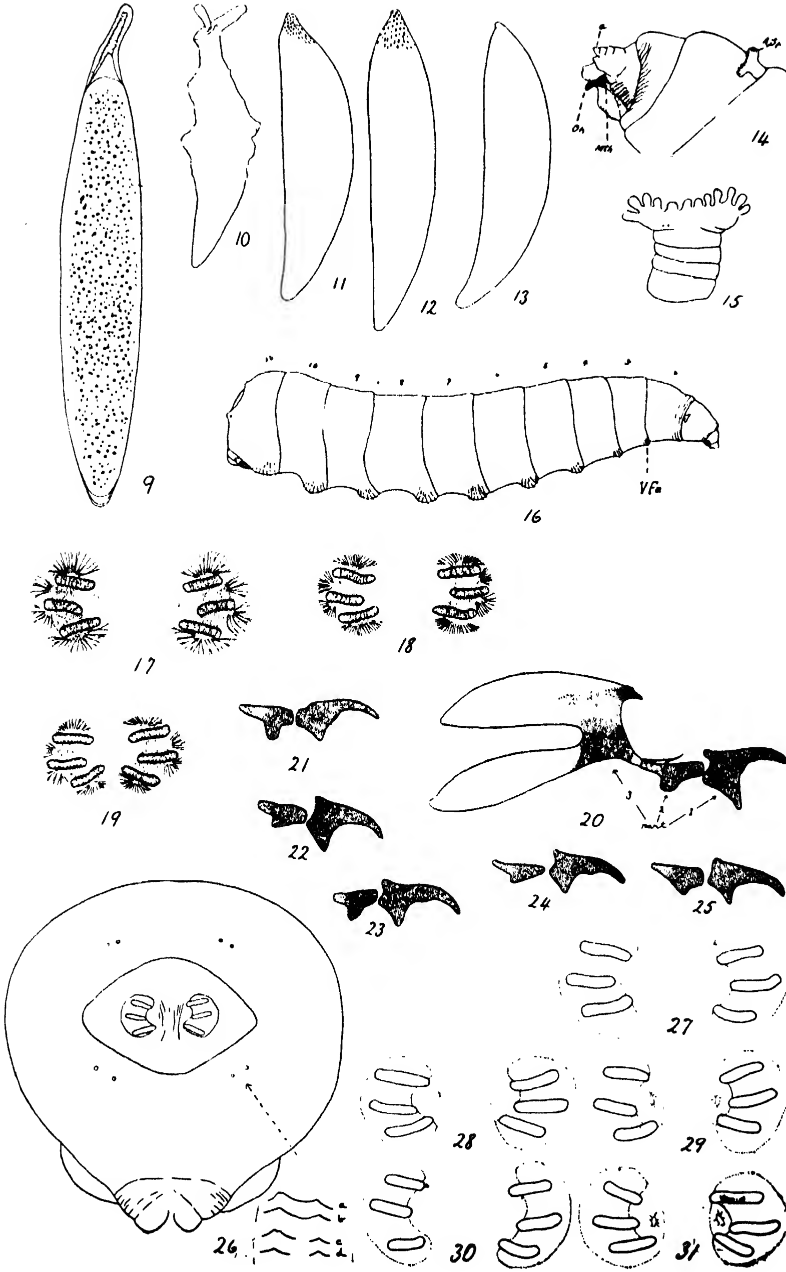

PLATE XII.

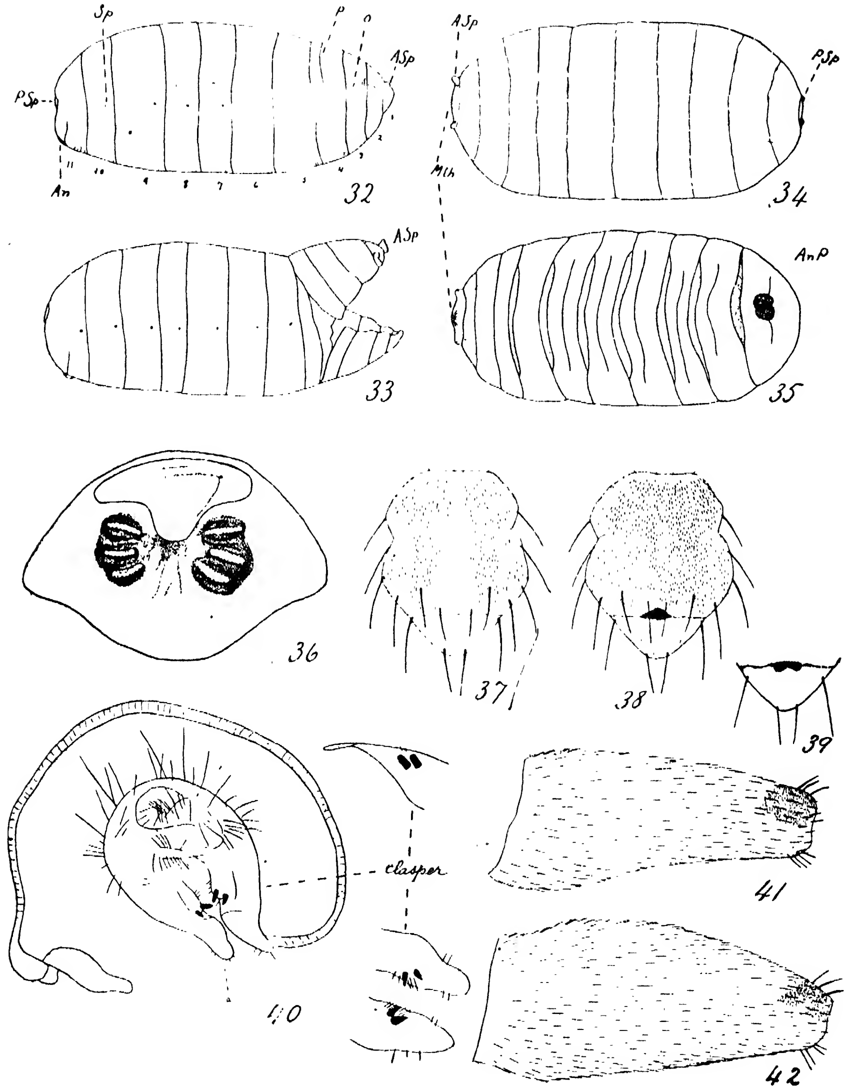

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PLATE XIII.

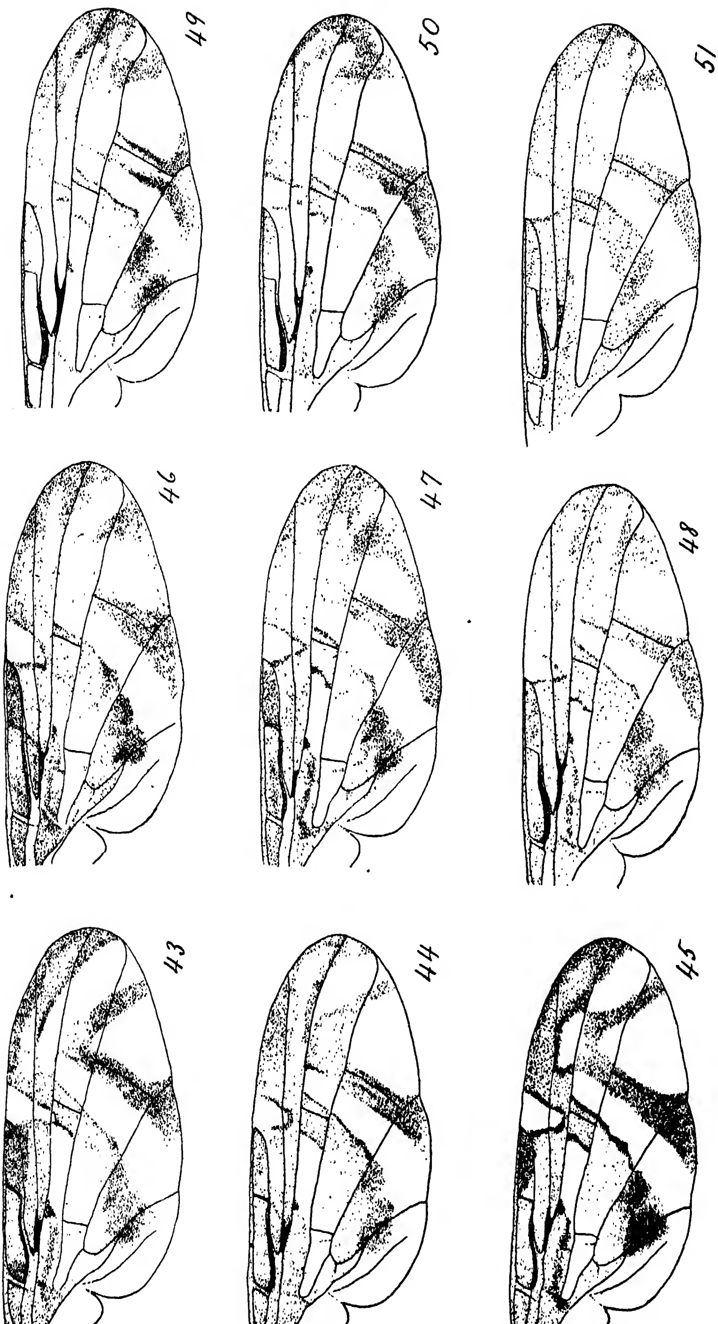
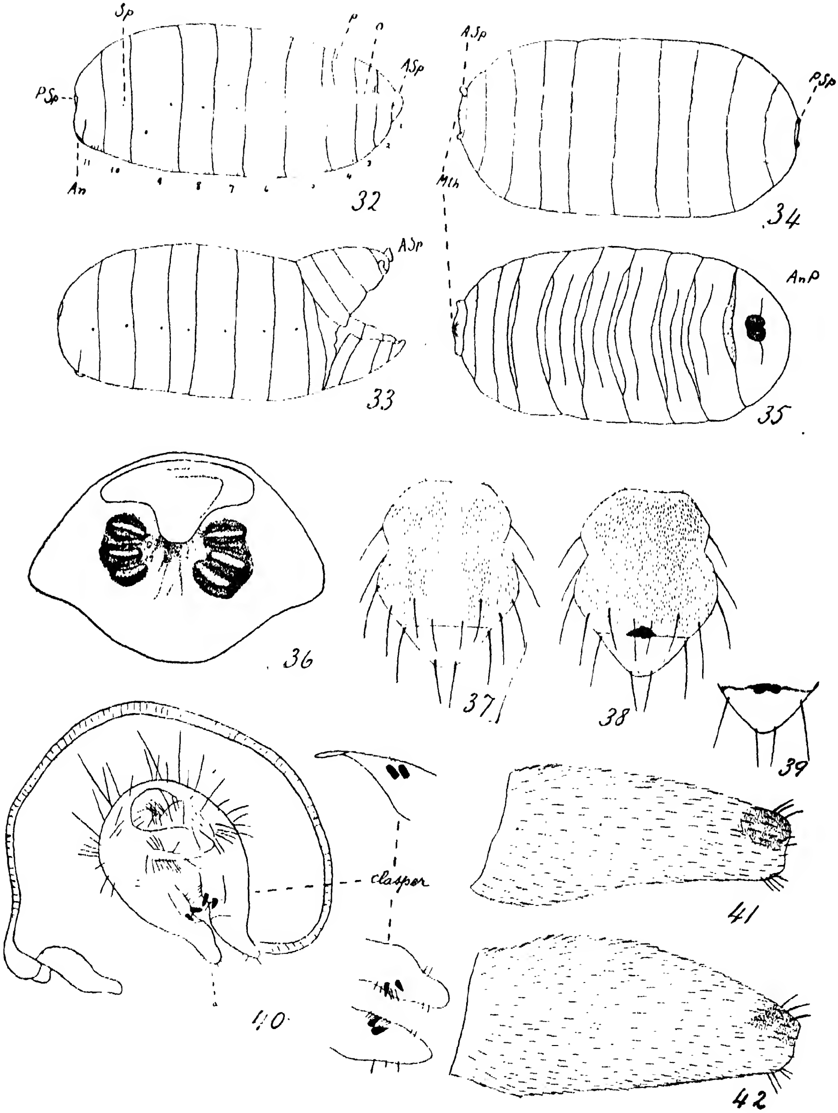


PLATE XII.



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THE EXTENT TO WHICH THE PRACTICE OF NOT BURNING CANE TRASH HAS BEEN ADOPTED IN PUERTO RICO

By GEORGE N. WOLCOTT, *Entomologist*,
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For many years, most entomologists working on the problem of the control of the sugar-cane moth stalk borer, *Diatraea saccharalis* F., have been of the opinion that the burning of cane trash in the field, either before or after harvesting, favored the borer because the fire destroyed its natural enemy, the egg-parasite, *Trichogramma minutum* Riley, and have therefore unceasingly recommended to cane growers that the trash should not be burned when the fields are to be ratooned. Only in Puerto Rico have these recommendations been at all widely adopted, but no definite data heretofore have been available to show the extent to which the planters were following the practise of cutting cane without burning the trash, and raking it into alternate rows to permit of cultivation and irrigation of the ratoon cane.

On April 3d, 4th and 5th, 1933, the writer, accompanied by Mr. Richard Faxon, in charge of the local unit of the federal Bureau of Plant Quarantine, and Mr. U. C. Loftin, Senior Entomologist of Cotton Insect Investigations, U. S. Bureau of Entomology, made a trip around the island, and noted every field readily observable from the road in which the trash had, or had not, been burned. Before giving the figures, it should be noted that non-burning the trash is essentially a negative practise, and that the trash had not been burned at the time of observation does not by any means indicate or prove that it might not be burned later. To more than compensate for this error, due to not being able to predict what might happen in the future, is the fact that if the trash is burned before cutting, this is readily observable even before the cane is cut, and is given credit under the heading of "burned". Furthermore, it is impossible to determine until a field is actually being plowed, whether it is to be left for ratoons or plowed for planting, and it is quite possible that some fields recorded as "burned" will eventually be plowed, and should not have been entered. No entomologist has considered recommending non-burning of trash in fields to be plowed for planting, yet one field was observed at Central Mercedita, Ponce, which was being fitted for planting, and in which, very obviously, the trash had not been burned. It should also be noted that the practise of burning cane

before cutting is most exceptional in Puerto Rico, yet it had been rather widely adopted this year in the northeastern corner of the island, where the damage to standing cane caused by the hurricane of San Ciprián, September 26–27, 1932, was greatest. In ordinary years, such a practise would practically never be followed in this part of the island.

In further explanation of the method used in making the observations, it should be stated that a field is considered to be any area, however large or small, receiving the same treatment at the same time. The enormous differences in size of field by this definition, might introduce a considerable error if only a few fields had been observed; but as the observations numbered five hundred four, it is considered that the figures as given present an essentially true picture. If the trash is burned in part of a field, and not burned in the other part, for the purpose of this investigation it is considered to be two fields.

Method of Disposal of Cane Trash in Fields to be Ratooned in Puerto Rico, observed at the height of the grinding season (April 3, 4 and 5) 1933.

Region	Trash not burned	Trash burned
San Juan to Maunabo (Northeast coast)	115	32
Maunabo to Ponce (Southeast coast)	81	7
Ponce to Mayagüez (Southwest coast)	85	14
Mayagüez to San Juan (Northwest coast)	146	24
Totals	227	77
Per cent	84.7	15.3

A YEAR'S EXPERIENCE WITH THE COTTONY CUSHION SCALE IN PUERTO RICO *

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and
FRANCISCO SEÍN, JR.
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The most complete yet succinct account of the Cottony Cushion Scale, or as it was earlier generally called, the Fluted Scale, and its accidental introduction into California, is that written almost a generation ago by Dr. C. L. Marlatt (**1**). This is quoted below entire, with one interpelating quotation from Dr. L. O. Howard, as it gives a picture of how the scale and its control were regarded and how this affected the then pioneering industry of citrus fruit production in California.

"Of all the scale insects attacking citrus plants, this species, (*Icerya purchasi* Maskell) is perhaps the most notable, not so much from the damage now occasioned by it as from the problems of control which it has brought to the front and the international character of the work which it has occasioned.

"The facts indicate that Australia is undoubtedly its original home, from whence it was introduced on Australian plants into New Zealand, Cape Town, South Africa, and California at about the same time. The evidence points to its introduction into California about the year 1868 on *Acacia latifolia*. It is a very hardy insect, will live for some time without food, and thrives on a great number of food plants. In California it spread rather rapidly, and by 1886 had become the most destructive of orange scale pests. The damage occasioned by it was of such a serious character as to threaten the entire citrus industry of the Pacific coast. The nature and habits of this insect made it almost impervious to any insecticide washes, and the orange growers of California were rapidly losing heart.

"In 1889 however, through the agency of Mr. Albert Koebele, an assistant of this office (the U. S. Bureau of Entomology), the natural

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*** Some of the observations on which this paper is based were made by one writer, some by the other, but in most cases they were made jointly by both at the same time. All of the rearing work, of the scale and of the lady-beetles, has been conducted by the junior author. For the past year, the senior author has been in charge of the work and the MS was written by him.**

ladybird enemy of the fluted scale was discovered in Australia and imported into California. This ladybird *Novius (Vedalia) cardinalis,* multiplied prodigiously, and in a very short time practically exterminated the fluted scale, saved the State of California annual damage amounting to hundreds of thousands of dollars, and removed this scale insect from the roll of dreaded injurious species."(**1**) Dr. Howard has thus evaluated this accomplishment: "This dramatic and extremely useful bit of work was a great thing for scientific economic entomology. So striking a success may probably never again be achieved in this country."(**2**)

"The beneficial results derived from this ladybird have not been confined to California. Through the agency of this Department (the U. S. Bureau of Entomolgy), and in cooperation with the California State authorities, this ladybird has been sent to South Africa, Egypt, Portugal, and Italy, and in each of these countries its introduction has been followed by similar beneficial results in the control of the fluted scale.

"While the fluted scale, at the time or soon after its injurious record in California, gained access to several foreign countries, very fortunately Florida and the Gulf districts remained long free from it.

"The first and presumably only introduction of this insect into Florida was an intentional one, though not malicious, and illustrates the risk run in importations of beneficial insects undertaken by persons unfamiliar with the subject. A nurseryman of Hillsboro County, Fla., hoping to duplicate against the common Florida scale insects the wonderful work of the imported Australian ladybird against the fluted scale in California and, ignorant of the fact that the ladybird in question did not feed on any of the armored scales which he especially wished to have controlled by it, got one of the county horticultural commissioners of California to ship him a lot of these ladybirds, together with some of the fluted scale as food. The whole lot was liberated on his premises and resulted, naturally enough, in stocking some of his trees very thoroughly with the fluted scale. The infestation coming to his attention, he sent, in June, 1894, specimens to the Division of Entomology and they were promply determined as the dreaded California scale pest. Fortunately, the nurseryman in question realized the enormity of his offense and took, at Dr. Howard's earnest suggestion, immediate and active measures to exterminate the fluted scale on his premises, ultimately taking out and burning the trees.

"It was hoped that extermination has been effected, but four years later (1898) the fluted scale was again received from the same dis-

trict. In view of its quite general spread, as reported, in the immediate region, it seemed improbable that it could be easily exterminated, and the introduction of the Australian ladybird was urgently advised. During the spring and summer of 1899 the ladybird in question was successfully colonized in Florida by Mr. Gossard, with the assistance of Mr. Craw.

"The fluted scale in Florida evidently does not multiply as rapidly as it does in California. Furthermore, as shown by Mr. Gossard, it is attacked by a fungous disease which appears suddenly in July and results in the death of from 25 to 70 per cent of the partly grown scales. We may hope that with the aid of this disease, and by means of the prompt introduction of its natural enemy, the fluted scales will never play the role in Florida which it originally did in California.

"The habits and transformations of the fluted scale closely parallel those of the species of *Lecanium* already described. The general appearance of the insect, however, is strikingly dissimilar, owing to the waxy excretions from the ventral plate of the adult female insect. There are ribbed, or fluted, from whence the insect takes it name, and become the receptacle of a vast number of eggs, a single female being the possible parent of more than a thousand young. The waxy material constituting the egg sac issues from countless pores on the under side of the body, especially along the posterior and lateral edges. As this secretion accumulates the body is lifted, so that ultimately the insect appears to be standing almost on its head, or nearly at right angles to the bark. The eggs are laid in the waxy secretion as it is formed, the waxy fluted mass often becoming from two to two and one-half times as long as the insect itself. The young are of reddish color, very active, and spread by their own efforts and by the agency of the winds, birds, and other insects. The female insect is, for the most part, a reddish orange, more or less spotted with white or lemon.

"The early stages of the male are similar to the corresponding stages of the female. Before appearing as an adult, the male insect secretes itself in some crack in the bark, or in the ground, and exudes a waxy covering, which forms a sort of cocoon, in which the transformations are undergone, first into the pupa and then into the adult insect. The winged male is rather large for a coccid, and has a reddish body with smoky wings.

"The rate of growth of the fluted scale is comparatively slow, and it does not normally have more than three generations annually.

This insect is quite active, the female traveling and moving about very freely nearly up to the time when she finally settles for egg-laying. The male is active up to the time when it settles down to makes its cocoon.

"The fluted scale exudes a great quantity of honeydew, and trees badly attacked by it are covered with the sooty fungus, characteristic of the black scale and the white fly.

"The remedy for this scale insect is always and emphatically to secure at once its natural and efficient enemy, the *Novius cardinalis*. Where this insect can not readily be secured, the scale may be kept in check by frequent sprayings with the kerosene or resin washes. Fumigation is comparatively ineffective against it, because the eggs are not destroyed by this treatment. Spraying is, for the same reason, effective only when it is repeated sufficiently often to destroy the young as they hatch."(**1**)

The above account of the cottony cushion scale and of its spectacular control in California has been reprinted here to indicate how generally it is considered that the problem of control of this pest is thoroly and completely solved. Yet upon examining the more recent publications from California, one discovers that control by the lady-beetle *Novius, Vedaliæ,* or *Rodolia cardinalis,* as it is now called, is by no means as effective as the earlier statements would lead one to suppose.

For instance, Prof. H. J. Quayle states that:

"While the cottony cushion scale is at present a pest of comparatively little consequence, it is still one of the commonest insects inquired about throughout the entire length of the State where citrus trees are grown. While the *cardinalis* is pretty well distributed over the State, and often appears unaided in an infestation of cottony cushion scale, yet in many cases it does not occur, and neither does the scale become very abundant. The checking of the scale in such cases must be accounted for through some other factors. Sometimes, too, the beetle is slow in getting the scale under control. On the station grounds at Riverside fifty or seventy-five orange trees have been infested with the cottony cushion scale, as bad as occurred when the insect was at its height, for at least four years. During this time also the ladybird beetle has been present. The scale becomes very abundant each spring when the *cardinalis* begins work and effectively checks them. The beetles are present in April, May, and June, and disappear in July. Some young scales are left and those have a chance to multiply and severely infest the trees again

before the *cardinalis* appears in the spring. This has been the history of the infestation for the past four years."(**3**)

Nor is the relative value of the parasites introduced by Koebele finally settled, for, to quote from a recent book by Dr. E. O. Essig: "The dipterous parasite of the cottony cushion scale, *Cryptochaetum iceryae* (Williston), was one of the natural enemies of *Icerya purchasi* Mask., introduced by F. S. Crawford and Albert Koebele from Australia into California in 1888–9. The adults are 1.5 mm. long, the head and the thorax metallic dark blue, and the abdomen iridescent green. They are rather slow in movement, crawling slowly over the cottony cushion scale inserting one to several minute, oblong, oval, smooth, pearly white eggs preferably in the half grown hosts. It is thought that a single female may lay as many as 200 eggs. The young larvae are curious, semitransparent elongated maggots with black mouth hooks, the anterior half of the body bare, the posterior half ciliated and with two long tail-like processes often twice the length of the body. The full-grown larvae are quite different. The body becomes pear-shaped with two horn-like tracheae and the tail-like processes extended to four or five times the length of the body. The color becomes reddish from the contents in the alimentary canal. The larvae live freely within the body cavity of the host feeding on the body fluids and apparently not seriously inconveniencing it; upon reaching maturity, however, the host is eventually killed. Several larvae may occur in a single scale insect. Pupation occurs within the dead body of the host. The puparia are yellow or reddish brown, oval, 2 mm. long, with two horn-like projections. There are five or six generations a year. This parasite is often the most important natural check on the cottony cushion scale, but because of its small size and the concealed manner of attack, it has not been given due credit for its efficiency. In the San Francisco Bay region it persists where the vedalia has long since passed away and keeps the scale insect under almost perfect control. Practically every lot of the scale sent to the University for examination shows the work of the fly and it is with great difficulty that living specimens of this once common and abundant scale insect can be secured for student study. In Southern California too this parasite has done much of the work claimed for the vedalia."(**4**)

Indeed, the whole problem of the cottony cushion scale, which was at one time thought to be finally settled and decided, is in fact still very much of a problem. If this is the condition in California, where the insect has been present for so long, and investigators have

been working on it ever since it first appeared, one may anticipate that its status in a new and entirely different environment may be even more subject to unusual and unexpected conditions.

The first published record of the cottony cushion scale in Puerto Rico is a note by Dr. W. A. Hoffman (5), of the School of Tropical Medicine in San Juan, who first observed it on a hedge of casuarina or Australian pine, *Casuarina equisetifolia,* in the patio of the School, later noting it generally on this host elsewhere in San Juan. (See Pl. XV.) This was not the first known occurrence, however, for it had previously been collected on rose bushes in Santurce, a suburb of San Juan, over a year previously, and determined by Dr. Harold Morrison of the U. S. National Museum at Washington. This record was not published until July, 1932(6), and then without special comment among hundreds of others, mostly of common or well-known insects. The early developments in the story of the cottony cushion scale in Puerto Rico are best told in an unpublished MS prepared by Dr. M. D. Leonard, at that time Chief of the Department of Entomology at the Insular Station. He said,—

"On October 21, 1931, Edmundo Martínez of the Insular Forest Service brought a small twig of Casuarina to the Station bearing two specimens of the cottony cushion scale. These had been brought to his Station by some woman of unknown name and address in Santurce, for identification. The extent of the infestation was not known. I sent these two specimens to Dr. Morrison under date of October 21, 1931 (the same day) for determination since I was not sure but that this might be *Icerya montserratensis.* I told Mr. Martínez at the time, however, that this was probably *purchasi,* the injurious citrus species, and urged that he and the other foresters be on the lookout for it on casuarina. I myself had often looked at the casuarina at the Forestal in Río Piedras but had seen no evidence of infestation by this or any other insect.

"On February 16 or 17, 1932, I received from Dr. Morrison a letter dated February 5, confirming my determination of the casuarina specimens as *I. purchasi.* I saw Mr. Martínez a day or two later at the Post Office in Río Piedras and told him of this and asked again that the foresters be on the lookout for it.

"At about the same time I told Mr. Faxon, Chief of the Federal Plant Quarantine Office, of this determination and asked that he and his inspectors be on the lookout for *purchasi* on both casuarina and citrus during their regular grove inspections.

"From then on I personally examined a number of casuarina trees and hedges around Santurce but saw none until the first week

in March when in company with Mr. C. E. Pemberton, Chief Entomologist of the Hawaiian Sugar Planters' Experiment Station, a light infestation was found on a few casuarina trees next to the Clínica Miramar at Stop 10, in Santurce. These were for the most part unhealthy looking insects and a considerable proportion of the few there had been eaten out by something.

"At this time I told Mr. Pemberton of the occurrence of *purchasi* here on roses and casuarina (both determined by Dr. Morrison) and concluded that it was so scarce and so restricted that nothing be done about control at that time.

"When Dr. Wolcott was in San Juan on March 4 and 5 to attend the International Sugar Cane Technologists' Congress, the infestation on the casuarina hedge at the Clínica Miramar had not yet been noticed. I next saw him on March 11 during the trip of the Technologists around the Island and on the 12th at Guánica told him of the occurrence of *purchasi* on roses and casuarina (3 infestations total only observed to date) and we examined many casuarinas in company with Dr. Pemberton. I still did not think it worth while to give this any publicity.

"I examined casuarinas at all stops in the Island tour between that date and March 15 but with negative results.

"On March 24, I believe it was, Dr. Wolcott wrote Commissioner Colón advising him, on my say-so, of the presence of *purchasi* in Puerto Rico and advised immediate extermination. I did not know this had been done however, until March 29. On this date I visited Mr. Barbour, Chief of the Insular Forest Service, to tell him that we had just recently discovered that the casuarina hedge in the Parque Muñoz Rivera in San Juan was generally infested and that light infestations occurred on one or two other hedges near the Union Club in Santurce. We also examined again carefully all the casuarina seedlings and larger trees at the Forestal with negative results. Mr. Barbour showed me a letter from Dr. Wolcott under date of March 19 urging that he watch carefully his casuarina seedlings in the nursery and saying that he had officially notified the Commissioner of the presence of *purchasi*.

"About this time Mr. Seín stated that he had found a rather bad infestation of what he had taken to be *Orthesia insignis* on the large casuarina hedge of the Colegio Puertorriqueño at Stop 15 in Santurce. The date was on February 26. This was now determined however as *I. purchasi*. He had recommended nicotine sulphate and soap. Some "gallego" plants, *Polysias Guilfoylei*, were also infested there.

"Based on Dr. Wolcott's notice of March 24th to the Commissioner, a meeting of the Insular Plant Quarantine Board was called on March 31 to consider possible measures to be taken against the cottony cushion scale. The history to-date in Puerto Rico was briefly reviewed and a resolution was made by Mr. López Domínguez and adopted to make a more thoro survey than had already been made of citrus and of casuarina especially in the vicinity of citrus groves as soon as practical and to determine, if possible, what agents may be holding the pest wherever it occurs.

"The next day, April 1, I visited Mr. Luciano's home in Santurce since Mr. Luciano had written me the day before that he had just observed parasites of the cottony cushion scale working there. There were present besides myself and Mr. Luciano, Messrs. Pemberton, and Anderson and Mills of the U. S. Plant Quarantine and Control Administration Office. A dipterous maggot was found working in the hollowed-out egg-sacks of the scale on the rose bushes and in some cases 3 or 4 puparia present in one empty egg-sack. Mr. Luciano stated that he had observed these rose bushes infested for about 2 years now and that the infestation was lighter now than formerly. There was no infestation on a number of casuarinas present in his garden. Two or three days later several small Phorid flies emerged from specimens of infested scales. This may possibly be *Syneura cocciphila* described from *I. purchasi* in 1895, from Mexico. Specimens were sent for determination to Washington thru Mr. Faxon's office by the boat of April 7.

"On April 2, Mr. Pemberton and I found that a number of scales in the lightly infested casuarina hedge alongside of the Olimpo Court Apartments at Stop 10, Santurce, were parasitized by the Phorid fly.

"Upon arrival at the Station Mr. K. M. Fletcher was there with a badly infested branch from his grapefruit grove at Palo Seco. He said a number of trees were infested, several badly so. Messrs. Pemberton and Seín and myself at once visited his grove and found that at least a dozen or fifteen trees had some branches badly encrusted with the insects and a number of other trees were lightly infested. Most of the trouble occurred on the first two rows next to a large bamboo windbreak along the road. A number of pigeon pea bushes next to the first row were also considerably infested. Mr. Fletcher stated that he had noticed this infestation over a month ago but it had just lately become much worse. He claims to have seen this insect present in his grove off and on in small numbers for the last

20 years. He had already scrubbed with brushes the larger branches of several trees previously, he said, badly infested.

"I recommended an oil or nicotine and soap spray at once and the immediate introduction of the Australian ladybird beetle.

"*April 4, 1932.* In the morning I went with Mr. Fletcher and Mr. Wildman (of the Isabela grove adjoining Mr. Fletcher's place) to see Commissioner Colón, and recommended introduction of the Vedalia beetles. I prepared a cable at once to the Florida State Plant Board requesting a prompt shipment of the beetles by air-mail.

"In the afternoon Fletcher's grove was again examined in company with representatives of the Insular and Federal Quarantine Services, Mr. Pemberton and Mr. Sims of the Nitrates Agencies.

"During the next few days I told several of the leading citrus growers about the infestation at Fletcher's and showed them specimens of the insect.

"On April 8, in company with Messrs. Anderson and Mills, of the Federal Plant Quarantine Office, we looked over Mr. John Kohn's (at Bayamón) casuarina windbreak and adjoining grape fruit trees as well as a number of rose bushes. Farther along the same road we found a light infestation on several trees in a large long casuarina windbreak and several grape fruit trees adjoining these as far as one tree in the 4th row from the windbreak lightly infested also. The Manager could not be located that afternoon.

"By previous arrangement I received from the Post Office in San Juan that night the shipment of 150 Vedalia puparia from Florida. They left Gainesville on the afternoon of the 5th.

"*April 9, 1932.* I had arranged to distribute the Vedalias in Mr. Fletcher's grove the first thing in the morning but was instructed by the Director to await the arrival of Dr. Wolcott who had been put in charge of the cottony cushion scale campaign by order of the Commissioner.

"*April 10, 1932.* The Director, Dr. Wolcott and I, released most of the Vedalias in Fletcher's grove in the morning—twelve boxes of them. Two boxes were put out on infested trees recently discovered in the adjoining Isabela grove and two were taken back to the Station. We then visited Mr. John Kohn and later arranged with the Manager of the Guildermeister grove nearby to start spraying with oil at once."

All the known occurrences of the cottony cushion scale in Puerto Rico up to that time were in San Juan and Santurce, or in citrus groves a few miles west along the coast, and widely separated by swampy marsh land, pasture or cane fields from the main citrus

producing section of the Island. The area was so limited in extent that for a time it seemed possible that the insect might be absolutely exterminated, if effective measures could be brought to bear upon it. The real difficulty was to determine what measures would actually be effective in extermination. A study of available literature showed only control measures, not extermination. By general admission, the lady-beetle *Rodolia* was only relatively effective, always leaving a few scales after cleaning up major infestations. Spraying was admittedly ineffective, and recommendations as to what to spray were vague and unsatisfactory. All that one could be sure of was that pruning of infested branches and destruction by fire of infested hosts would certainly eliminate those scales at least. Such treatment was quite practical in some cases, but hardly applicable generally in Isabela Grove, the largest single citrus property on the Island. As a matter of fact, however, the infestation in this grove was soon found to be so general that both spraying and pruning were generally adopted, and temporarily held the pest in check. In the adjoining grove, Mr. Fletcher had had little success in spraying with prepared oil sprays, consequently the old fashioned "cold-stirred" emulsion, with an excess of whale oil soap, was used in Isabela Grove.

Thru the co-operation of Mr. Fletcher and Mr. Kohn, a power sprayer was made available for immediate use by the Department of Agriculture in spraying casuarinas in San Juan, and as soon as funds were made available in the next fiscal year, a new power sprayer was purchased for this work. The conduct of spraying operations was under the supervision of Mr. Adolfo Mayoral, who previously had considerable orchard-spraying experience. He carried on extensive experiments to determine the relative merit of various sprays, and as a result, later sprayings were confined to the use of "Kerecide", a local preparation of standard composition which used fusel oil as stabilizer. His experiments showed that no spray is of much value during showery or rainy weather; but during dry weather, this heavy oil spray gives close to 100 per cent control. San Juan is an island, and most of the infestations in Santurce are close to the ocean, in some cases the casuarina trees being actually on the beach. It is under such conditions that the heavy oils give best results. Little is known about the effectiveness of this or other sprays under inland conditions, for up to the present no similarly extensive inland infestations have been available for experimentation.

Spraying and pruning operations having been gotten under way in localities where infestations were known to exist, the next step was to determine, if possible, all infestations. All available means

of publicity were used. Dr. Jaime Bagué, Sub-Commissioner of Agriculture, made announcements over the local radio broadcasting station. He also supervised the preparation of a poster, showing by reproductions of photographs of the insect on casuarina, what the insect looked like and requesting that all suspicious material be submitted for inspection. The text of the poster is as follows:

GRAVE PELIGRO PARA NUESTRA AGRICULTURA

La Cochinilla Blanca ha aparecido recientemente en los pinos australianos, rosales y toronjales de San Juan y sus cercanías.

Esta plaga es sumamente peligrosa; pues en una época casi acabó con los naranjos en el Estado de California.

Si usted encuentra dicho insecto en su jardín o en su huerto, ponga varios ejemplares en un frasco y envíelo a la Estación Experimental Insular, Río Piedras, P. R.

Coopere con nosotros a salvar la industria de toronjas de Puerto Rico que representa millones de dólares para el país.

A short descriptive article was circulated by both the fruit-growers' organizations, and write-ups appeared in San Juan newspapers. The aid of the Boy Scouts of the San Juan region was enlisted. Regional meetings of the Agricultural Agents were held in Río Piedras, Isabela, Ponce and Guayama, at which they were shown photographs of the insect (no live material was carried around the Island), and instructed to be on the constant look-out for infestations. While en route between these meetings, the senior writer inspected many casuarina trees, especially along the east and northeast coast. Later, a special inspection was made of the casuarinas and orange trees along the beach east from San Juan as far as Río Grande, the results being entirely negative.

The immediate returns from this publicity were encouragingly meagre. A few spider webs on casuarina needles were submitted by one anxious citrus grower, for these webs in size and color at least superficially resemble mature scales. Mr. Mariano Mari, in charge of the Demonstration Farm near Arecibo, noted an extensive infestation of the native cottony scale, *Icerya montserratensis* Riley & Howard, on orange, which he thought might be mixed with *Icerya purchasi* because many of the scales lacked the long waxy projections secreted by the native species. (See Plate XVI.) His suspicion was shown to be justified, when, a few days later, another infestation of *Icerya montserratensis*, on a single citrus tree at the Poultry Sub-Station at Pueblo Viejo, was discovered to be mixed with the Australian species. Several other large infestations were soon afterwards found in Pueblo Viejo, and a number of infestations in the

main Bayamón citrus district. A suburban resident on the Trujillo Alto road reported some scale on a rose bush which had been presented to him by a friend in Santurce. Scales were also found on the casuarinas besides the Las Monjas racetrack between Río Piedras and Santurce. All of these new records, however, were in the immediate vicinity of San Juan, and except in the one case where the scale had obviously been carried on the host, were to the west and southwest. No infestations were found to the east or far to the south, indicating that normal dispersion was resulting from the prevailing winds (from the east and northeast), and that this was by far the most important single factor in dispersion. (See Plate XVII.)

Even before the results of the publicity campaign were beginning to come in, Dr. Hoffman reported another infestation on causarina and citrus, west of Dorado, ten or twelve miles in an airline from San Juan and seven or eight miles west of Isabela Grove. At first this seemed to be an isolated outbreak, but later and more careful observations in this region disclosed an infestation in a few citrus trees just outside of Dorado. That only two infestations were discovered in this region is largely due to the scarcity of appropriate hosts, most of this region being in cane, pasture or coconuts. Their presence, however, and the complete absence of infestation east of San Juan, despite an abundance of suitable hosts, confirms the original observations on the importance of the prevailing wind as an agent in dispersion.

Farther west of Dorado than Dorado is west from San Juan, a small infestation was much later discovered on a windbreak of casuarinas in the hills back of Barceloneta, on the Florida road. This might have resulted from the scale being carried on an automobile, for the casuarinas were close to the main road into the grove, but it seems more likely that this infestation represents another chance wind infestation, a jump of at least twenty miles from the nearest other known infestation.

Just as the prevailing wind is the most important factor in natural dispersion of the cottony cushion scale, so humidity is the most important factor determining abundance. The north coast of Puerto Rico, where all known infestations of cottony cushion scale occur, has an annual rainfall of from 50 to 90 inches. The distribution of the rainfall is by no means uniform thruout the year, and in general the late winter and the spring months are the dryest. The cottony cushion scale has unquestionably been present for several years in Puerto Rico, but it appeared in noticeable and distinctive

abundance only during the exceptionally dry spring of 1932. As the spring advanced, new infestations were discovered every few days, and despite a strenuous campaign of spraying and pruning, new areas of even denser infestation were constantly appearing in unsprayed parts of groves. The limited numbers of the Australian lady-beetles that could be released seemed quite unable to make an impression in the unsprayed areas where they had been released. During February, March and the first three weeks in April, 1932, less than an inch of rain per month fell anywhere in the infested area, and it was towards the end of this prolonged drought that the scales became most numerous.

The situation changed in May, 1932, when the average rainfall for the region was nearly 13 inches, and during June, July and August, averaged over 7 inches per month. For periods of four or five days at a time, rainfall would be almost continuous, and humidity would remain high, even when rain was not actually falling. Temperatures were also high during most of this period, not only during the day but all night long. It was a most uncomfortably hot and humid summer for people living in and near San Juan, and it was deadly for the cottony cushion scale. In citrus groves well protected by windbreaks, humidity remained high at all times, and, fortunately for the growers, most of the infestations were in windbreak-protected blocks. Isabela Grove, despite its proximity to the ocean, is exceptionally well protected, for the citrus trees were originally planted in clearings thru primeaval forest, and this natural windbreak has been constantly reinforced since. When the grove was examined in July, not a single live scale could be found. When one considers that thousands of trees in this extensive property had been infested only two and a half months previously, and new outbreaks were constantly being discovered on unsprayed trees so fast than all the spraying equipment available could not treat them, the contrast was amazing. A few lady-beetles had been released in this grove, but not a trace of them could be found in July, and their presence at any time could have been only a very minor factor in the elimination of the scale. Practically all of the infestations were found covered with a greyish-white fungus, never before observed in Puerto Rico. Thru the courtesy of Miss Vera K. Charles, this fungus was identified as *Spicaria* sp., and Mr. E. West of the Florida Station states that it is identical with what they call *Spicaria javanica.*

Very heavy infestations of limited extent on citrus trees in pockets in the hills around Bayamón showed even more beautiful examples

of complete and very recent destruction of the scales by this fungus. Its distribution was not extensive at first, however, and on one scale infestation discovered at this time on a citrus grove in Pueblo Viejo which had shortly previously been sprayed with Bordeaux, none of the fungus was to be observed. The owner brought leaves and twigs covered with fungus-killed scale from Isabela Grove, and placed them in one tree, otherwise untreated, between others which he sprayed with kerosene emulsion. Two weeks later, all the scale had been killed on the tree where the fungus had been introduced, while many scales were still alive on the sprayed trees. Naturally the owner was enthusiastic about the value of the fungus, and he was rapidly placing leaves with fungus-killed scale in all parts of his grove. Fortunately for the success of his experiment, humidity remained high for several weeks thereafter, and when examined a month later, not a single live scale could be found in his grove. Another report of scale infestation, which could not be examined immediately, was later found to have been completely eliminated by the fungus.

Continuously high humidity for several days is absolutely essential for the successful use of *Spicaria*. This was abundantly demonstrated in one grove where the scale infestation extended from a knoll-protected hollow to the top of a wind-swept hill. Within a few weeks, not a scale was to be found in the hollow, but as one went up the hill, infestations increased in intensity. The citrus grove at Dorado was very imperfectly protected from the wind, and here the fungus never appeared. Its requirements of humidity are more exacting than of a similar entomogenous fungus, *Cephalosporium lecanii,* which in the nursery at Dorado killed many hemispherical scales, *Saisettia hemispherica* Targioni, and green scales, *Coccus viridis* Green, on young seedlings also infested with cottony cushion scale. Experimentally, smears of its spores rubbed on scales on casuarina trees by Dr. Mel. T. Cook, of this Station, gave entirely negative results in control. Apparently casuarina trees, generally planted as windbreaks, retain with their needle-like leaves too little humidity on themselves to permit of this fungus being of much value for killing scales on them. Temperature is not so important, for even at minimum winter (tropical) temperatures, *Spicaria* is at least partially effective, as was later indicated in a grove at Bayamón, observed in January 1933, with many freshly killed scales.

The entomogenous fungus, *Spicaria javanica,* is by far the most important factor in control of cottony cushion scale during rainy weather and under generally humid conditions. It is, however, not the only agency attacking the scale in addition to the introduced

lady-beetles. Mention has already been made, in Dr. Leonard's MS report, of the discovery of Phorid flies attacking and developing within mature scales, and his tentative determination of these flies was later confirmed by Messrs. C. T. Green and J. R. Malloch as *Syneura cocciphila* Coquillet.

"The next most important natural enemy in Puerto Rico is the lace-wing fly, *Chrysopa collaris* Schneider. The trash-carrying larvae were usually found feeding in colonies of the scale, often commonly so, and a number of adults were reared. The pupal period occupied only 5 or 6 days.

"The common lady-beetle, *Cycloneda sanguinea* L., was frequently found feeding both as adult and larvae on the scales and the larva of a moth, undoubtedly *Ereuntis minuscula* Wlsm. was several times observed making heavy inroads where the scales were thickly encrusting twigs or small branches."(7)

Even more interesting was the discovery by the junior author, who was handling all the rearing work of the lady-beetles, that, among the scales brought in from Dorado as food for them, a few much smaller lady-beetle larvae were already present. They pupated when less than half the size of *Rodolia* larvae, the adults emerging being small, light red beetles, quite different from *Rodolia cardinalis* in size and color markings, and indeed differing from anything in the Station collection. They were entirely light red in color, except for black eyes, a black spot on each elytron, and a black margin at the base of the elytra and extending for a short distance along the sutural margin. The first specimens reared were sent to Washington for determination and Dr. Chapin replied that they were a new species. Later, additional immature material was collected at Dorado, which, together with other adults, was sent to the National Museum, where technical descriptions have been prepared by Drs. Chapin and Böving (8 and 9), the insect being named *Decadiomus pictus* Chapin.

A minute wasp parasite, *Cheiloneurus pulvinariae* Dozier, as determined by Mr. C. F. W. Meusebeck, was reared from cottony cushion scale by the junior writer in May, 1932. This parasite was originally described by Dr. Dozier from material reared from a soft scale of sugar-cane, *Pulvinaria icerya* Newstead, but which he considered as being "a hyperparasite on the primary parasite of this scale, *Aphycus flavus*, with which it is always reared."(10)

The original host in Puerto Rico of both this and the other recently discovered insects predaceous and parasitic on cottony cushion scale is the not very common native cottony scale, *Icerya montserra-*

tensis R. & H. The larvae and adults of *Rodolia* will also feed on this native scale, at least in captivity and indeed a few of them have been reared on this scale when a sufficient supply of the Australian species was not available. The Phorid fly, *Syneura cocciphila* was originally, according to a letter from Dr. Aldrich, "collected from *Icerya purchasi* at Victoria, Mexico, October 16, 1894; Magdalena, Sonora, Mexico, September 26, 1894; Tamaulipas, Mexico, November 30, 1894. These are records from the type material. Other specimens (in the National Museum collection) are from Sao Paulo, Brazil, collected by A. Hempel, January 1899, from *Icerya brasiliensis.*" To this is now added the rearing record from the native scale. One parasite which has been reared only from the native scale is a small yellow Braconid wasp, of which the antennae, eyes and wing veins are black, determined by Mr. C. F. W. Muesebeck as *Rhyssalus brunneiventris* Ashmead.

The high humidity of the late spring and early summer of 1932 was not only highly destructive of cottony cushion scale, but it also made the artificial rearing of the predaceous *Rodolia* lady-beetles extremely difficult. In all discussion of the rearing work, it must be kept in mind that no infestation of cottony cushion scale occurs within several miles of the Experiment Station at Río Piedras, and it was not considered a desirable policy to establish colonies there in the open, while facilities for rearing large supplies of food for the lady-beetles were not available under cover. Consequently, scales had to be brought in from elsewhere to feed the beetles, and often most of the scales collected at this time were either dead or dying from fungus attack, or became infected immediately they were brought to the insectary. In this emergency, the casuarina hedge in the patio of the School of Tropical Medicine, where Dr. Hoffman had first observed the scale, and where it was still abundant, proved of great value in keeping a supply of the beetles alive. Only a few pairs were released there originally, but they throve to such an extent that their progeny soon spread to adjacent scale-infested casuarina trees of the grounds around the U. S. Army barracks. By the middle of September, hundreds of pupae could be collected here, and releases of beetles were made in all citrus groves where infestations of the scale still existed. The combination of fungus in windbreak protected groves, with ladybeetles in those where protection from the wind was less perfect, had by the middle of September 1932, reduced infestations in citrus groves to insignificant numbers. Indeed, it was rapidly becoming difficult to find places where beetles could be released to advantage, for the supply of food in sight for them was

so limited. Had such conditions continued for only a short period longer, absolute extermination, which seemed so visionary six months previous, might have become a fact.

In certain groves, the destruction of cottony cushion scale by *Spicaria javanica,* not only approached, but actually was 100 per cent perfect. If such conditions had been general, the problem would have been solved. In reality, however, certain parts of infested groves were so poorly protected by windbreaks that the fungus had little effect, and on the casuarina trees and hedges of San Juan and Santurce, none at all. In a very few cases the *Rodolia* beetles destroyed every scale insect present, but in most cases a few scales would be found even where beetles were repeatedly released. It was apparent that there was not enough food present to feed many lady-beetles or their larvae, but they usually failed to eat up even that little. Where only a few scales were left on a small tree, these could be destroyed by hand-picking; but to care for other infestations on larger hosts, or widely scattered in a grove, some other means must be used. The statement of Prof. Essig regarding the relative efficiency of the Agromyzid fly, *Cryptochaetum iceryae,* and *Rodolia* (already quoted), was so unequivocal that it seemed desirable to attempt the introduction of this parasite into Puerto Rico, and see if it would clean up what the beetles left. Mr. S. A. Rohwer, Acting Chief of the U. S. Bureau of Entomology, referred the request for a shipment of these flies to Dr. Stanley E. Flanders of the Citrus Experiment Station, Riverside, California, for favorable action.

This was the picture in the latter part of September, 1932: cottony cushion scale absolutely eliminated in some groves where it had previously been very abundant, and greatly reduced everywhere else thru the activities of the lady-beetles, of which an over-abundant supply was available for release and distribution. Even had the beetles failed, we knew what spray would give greatest effectiveness in control under local conditions, and an adequate sprayer and a trained spraying crew was available for any emergency. In addition, a shipment of the Agromyzid parasite, *Crytochaetum iceryae,* was confidently expected in the near future. To be sure the distribution of the scale was quite extensive, but the situation was entirely under control and only time and a continuance of well organized activities were needed to successfully complete the campaign.

During the night of September 26–27, 1932, the hurricane of San Ciprián swept the northern coast of Puerto Rico and entirely changed the status of the cottony cushion scale. As was reported by the senior writer immediately afterwards, the hurricane had but little ef-

fect on soil insects, or on those living where they were well protected against its onslaught, but scale insects of all kinds suffered greatly. "The trunks and branches of trees exposed to the full force of the wind are smoothed of rough bark and all projections in a most surprising manner. Of course some scales persist in the crotches and on the petioles of leaves, but the breaking off of leaves, twigs and larger branches causes an immediate decrease in their numbers only exceeded by the mortality caused by the direct action of the wind and rain in rubbing the insects from their host."(**11**) Not only such large, fluffy and easily dislodged scales as *Icerya purchasi* were blown off of their host, but those with a tough, hard scale, closely appressed to the host, were also carried away. It was the rule, and not the exception, that 95 to 99 per cent of all the purple scales, *Lepidosaphes beckii* Newman, on citrus trees in the region affected by the hurricane, were removed overnight. In the next few weeks after the hurricane, no sign of cottony cushion scale could be found, even on hosts known to have been infested before the hurricane. Of course not every egg and every crawler had been destroyed, but it was a matter of months before the few surviving individuals could be found.

So far as can be determined from observations made in the following six months, the hurricane did not extend the distribution of the scale at all. No new infestations have been found since the hurricane, and apparently its actual effect it to destroy all those blown off the host, and not to carry them uninjured to a new host, miles away. The force of the hurricane wind is too great, and is destructive, rather than dispersive, of these soft, fluffy insects.

Just a month after the hurricane, a shipment of scales heavily infested with *Cryptochaetum iceryae* was received. This shipment was mailed at Riverside, California on October 18th, 1932, and was delivered at the Station in Río Piedras on the 25th, having been sent by air-plane mail. Thirty flies had already emerged en route, and these were released on the date of receipt in two, protected casuarina hedges in Santurce where a very few large cottony cushion scales had survived the hurricane. For the next weeks, releases were made of twenty or thirty flies every other day in every place where scales were known to have been present before the hurricane, even tho none could be found at the time of release of the parasite. A few weeks later, when scales were more apparent, daily hand collection was organized in San Juan and Santurce, but not a fly emerged from any of this material collected where the releases had been made. Nor were any flies reared from scales collected in citrus groves where releases had been made, and it appears probable that the introduction

was a failure, largely because the sending was received at a time when so few scales were available to be parasitized.

This imported Agromyzid fly was not the only insect dependant on cottony cushion scale, of which greater numbers were present immediately after the hurricane than could be fed. Because of lack of food for them, or any means of obtaining it, all the live *Rodolia* beetles at the Station had to be released in a citrus grove in Bayamón which before the hurricane represented the heaviest infestation of scale known at that time. Besides these beetles in captivity, some in the open also survived the hurricane. That casuarina hedge in the patio of the School of Tropical Medicine, on which Dr. Hoffman had first observed the scale on this host, and on which *Rodolia* was breeding at the time of the hurricane, was so well protected against the force of the wind by the three story building of the school as to be practically undisturbed. On October 6th, ten days after the hurricane, about thirty fresh (unemerged) beetle pupae were noted on this hedge. They were not collected for release of the beetles elsewhere, for scanty as was the prospective supply of food for them on this hedge, just then it represented more of large scales than was present is all the rest of Puerto Rico. These few *Rodolia* beetles were all that survived the hurricane, and practically all of their progeny perished soon after from lack of food.

So far as is known, *Rodolia* beetles survived the post-hurricane scarcity of food in only one place. In January 1933, a single beetle was noted by Mr. Richard Faxon on some scale infested pigeon pea bushes growing across the street from his office in the Ochoa Building, possibly a mile to the west of the School of Tropical Medicine. In the next few weeks, a number of fresh (unemerged) pupae were collected here, to form the nucleus of renewed breeding operations at the Station.

Thru the courtesy of Dr. C. L. Marlatt, Chief of the Bureau of Entomology, a shipment of *Rodolia* beetles was received from the Cottony Cushion Scale Laboratory of the Bureau, at New Orleans, being mailed there by Mr. A. W. Cressman on February 7th, 1933, and received at the Station in Río Piedras on the morning of the 11th. This shipment contained 35 pupae when it left New Orleans, several of which transformed to adult en route, and all arrived alive and vigorous. Combined with the few beetles collected from the pigeon pea bushes opposite the Ochoa Building, this shipment gave the Station an ample supply for breeding, so that hundreds of beetles were ready for release by the middle of the spring of 1933.

The hurricane of San Ciprián unuestionably destroyed 99 per cent or more of all the cottony cushion scale alive in Puerto Rico on September 26, 1932, and for the first few weeks afterwards, no scale could be found. But a few individuals had survived, and in the succeeding months they were able to reproduce more rapidly than before because the hurricane had even more completely swept away their natural enemies, even including windbreaks. At first it seemed as tho it might be possible to destroy these few survivors, and a careful and intensive search was made in every place where the scale was known previously to have been present, and every individual discovered was collected or destroyed by hand. Young scales were found in various protected locations on the host, between petioles and twig, in crotches, and in greatest numbers at the edge of the callus growing over the wound where a branch had been sawed off. An obvious clue to their discovery on citrus trees was a line of the fire ant or "hormiga brava", *Solenopsis geminata* F., which had promptly adopted this Australian immigrant, and entered into even more active symbiosis with it than with most native soft scales and mealybugs. As a general rule, citrus trees with no ants are free from "honey-dew" producing mealybugs or soft scales. Where ants were present, young colonies of cottony cushion scale (or some other soft scale, or mealybug) were almost invariably present also. The hurricane had doubtless destroyed much of the usual food of the fire ant, and they were in consequence especially solicitous to preserve and care for any insect able to provide them with "honey-dew". In numerous cases they were observed to have built a structure of carton and earth over young colonies of cottony cushion scale located on callus margins of wounds, such structures being reminiscent of hurricane sheds, or "tormenteras", altho all were constructed after the hurricane, rather than before. Gradually, as the citrus trees put out new leaves, the scales began to appear exposed on the new leaves and on twigs, having left their pseudo-tormenteras and no longer receiving such intensive care from the ants.

During the remaining months of 1932, the numbers of the scale increased slowly, but with the beginning of dry weather in the early months of 1933, a very considerable increase in their numbers became apparent. In not a single place had the scale been entirely destroyed, despite constant watchfulness and hand collection. The earlier outbreaks on casuarinas in San Juan and Santurce were controlled by spraying, and by organizing a system of daily hand collections from a few trees which were not sprayed, an adequate supply of food was maintained to rear and have ready for general distribu-

tion hundreds of *Rodolia* beetles early in March. Because such an abundance of the beetles, lacking in 1932, was available and was released this year, no such tremendous increase in abundance of the scale as occurred in the spring of 1932, paralleling the practical absence of rainfall, was to be expected this year. Approximately three thousand beetles were released in March, April and May of 1933, effectually checking all incipient outbreaks and so thoroly cleaning up others as to almost approximate local extermination.

SUMMARY

1. The Cottony Cushion, or Fluted Scale of Australia, *Icerya purchasi* Maskell, is known to have been present on rosebushes in Puerto Rico since early in 1931, and presumably had been present for some time previously.

2. It first appeared in noticeable and destructive abundance on casuarinas (Australian pines) in San Juan and Santurce, and in citrus groves mostly less than ten miles to the west and southwest of San Juan, during the exceptionally dry spring of 1932.

3. Natural dispersion of the scale is by the prevailing north-east winds: from the original focus in San Juan and Santurce to the west and southwest.

4. In the citrus groves well protected by windbreaks, the scale was entirely eliminated by an entomogenous fungus, *Spicaria javanica,* never before recorded from Puerto Rico, which attacked it during the extremely wet weather of May 1932, and persisted during the following humid summer months.

5. The Australian lady beetle, *Rodolia (Novius) cardinalis* Mulsant, brought to Puerto Rico by airplane from Florida and later from New Orleans, is reasonably efficient in cleaning up scale infestations in less humid locations, such as exposed citrus groves, and on casuarinas growing close to the ocean or planted to serve as windbreaks.

6. Of native parasites, the most important is a Phorid fly, *Syneura cocciphila* Coquillet, originally described from Mexico, and never before found in Puerto Rico. The scale is also attacked by a wasp, *Cheiloneurus pulvinariae* Dozier, described from Puerto Rico, and by a small lady-beetle, *Decadiomus pictus* Chapin, a new and previously undescribed species.

7. During dry weather, almost perfect control is obtained by spraying with a standard heavy engine oil-fish oil soap emulsion, of which fusel oil is the stabilizer.

8. Except in special instances where especially well protected by

high buildings, all the large scales and practically all the small scales were carried away and destroyed by the hurricane of San Ciprián, September 26–27, 1932. A few scales in protected locations on their hosts escaped destruction and were later able to increase rapidly in abundance because the hurricane had been even more destructive of their natural enemies.

9. So far as can be determined, the hurricane had no effect in the dispersion of the scale.

List of Illustrations:

PLATE XV

The Cottony Cushion Scale, *Icerya purchasi* Maskell, on Casuarina or Australian Pine, *Casuarina equisetifolia.* Natural Size. (Photograph by Guillermo Rodríguez.)

PLATE XVI

The Cottony Cushion Scale, *Icerya purchasi* Maskell, (left) and a native cottony scale, *Icerya montserratensis* Riley & Howard, (right) on Casuarina or Australian Pine, *Casuarina equisetifoliæ.* Twice natural size. (Photograph by Guillermo Rodríguez.)

PLATE XVII

The Known Infestations of the Cottony Cushion Scale, *Icerya purchasi* Maskell, in Puerto Rico, before the Hurricane of San Ciprián, September 26–27, 1932:

Smaller cities and towns referred to in the text indicated by circles; infestations by solid black areas. (Original.)

PLATE XVIII

Outline map of Puerto Rico showing by Dots the Extreme Limits of Dispersion of the Cottony Cushion Scale, *Icerya purchasi* Maskell. For details of exact location of infestations, see Pl. XVII. (Original.)

BIBLIOGRAPHY

1. **Marlatt, C. L.**—"Scale Insects and Mites on Citrus Trees". Farmers' Bulletin No. **172**, U. S. Dept. Agr., p. 42, fig. 34, many refs. Washington, January, 1915. (See pp. 32–36.)

2. **Howard, L. O.**,—"A History of Applied Entomology (Somewhat Anecdotal)". Publication 3065, Smithsonian Miscellaneous Collections, Vol. **84** (whole volume), p. 564, pl. 51. Washington, November 29, 1930. (See p. 99.)

3. **Quayle, H. J.**,—"Citrus Fruit Insects". Bulletin No. **214**, University of California Publication, pp. 441–512, fig. 74. Berkeley, May, 1911. (See pp. 470–471.)

4. **Essig, E. O.**,—"Insects of Western North America". pp. 1035, fig. 766, many refs. The Macmillan Co., New York, 1926. (See pp. 615–616.)

5. **Hoffman, W. A.**,—"*Icerya purchasi* in Puerto Rico". Jour. Econom. Ent., **25**(3): 726. June, 1932.

6. **Leonard, M. D.**,—"Insect Conditions in Puerto Rico during the Fiscal Year, July 1, 1930–31". Jour. Dept. Agr. Puerto Rico, **16**(2): 121–144. April 1932. (Issued July 1932.) (See p. 138.)

7. **Leonard, M. D.**—"The Cottony Cushion Scale in Puerto Rico". Jour. Econom. Ent., **25**(5): 1103–1107. October 1932.

8. **Chapin, E. A.**,—"A New Genus of West Indian Coccinellidae (Coleoptera)." Proc. Biological Soc. Washington, 46: 95–99, pl. 1. April 27, 1933.

9. **Böving, A. G.**,—"Description of the Larva of *Decadiomus pictus* Chapin (Scymnini, Coccinellidae)." Proc. Biological Soc. Washington, 46: 101–104, pl. 1. April 27, 1933.

10. **Dozier, H. L.**,—"An Outbreak of the Red-Striped Sugar Cane Scale". Jour. Dept. Agr. Puerto Rico, **9**(4): 357–367, fig. 4. October 1925. (See pp. 363–365).

11. **Wolcott, G. N.**,—"The Effect of the Hurricane of San Ciprián on Insects in Puerto Rico". Insect Pest Survey Bulletin, **12**(9): 409–410. Washington, November 1, 1932.

PLATE XV.

PLATE XVI.

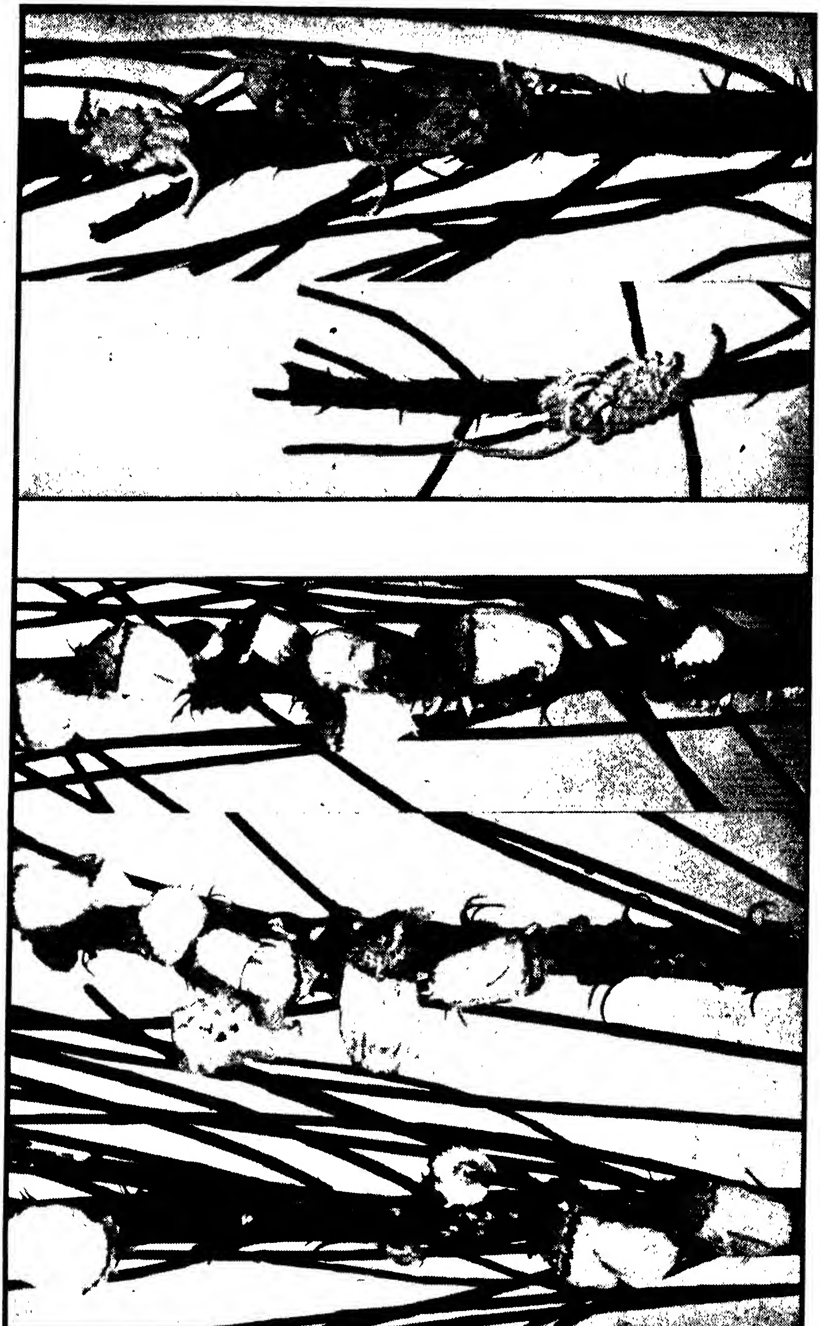


PLATE XVII.

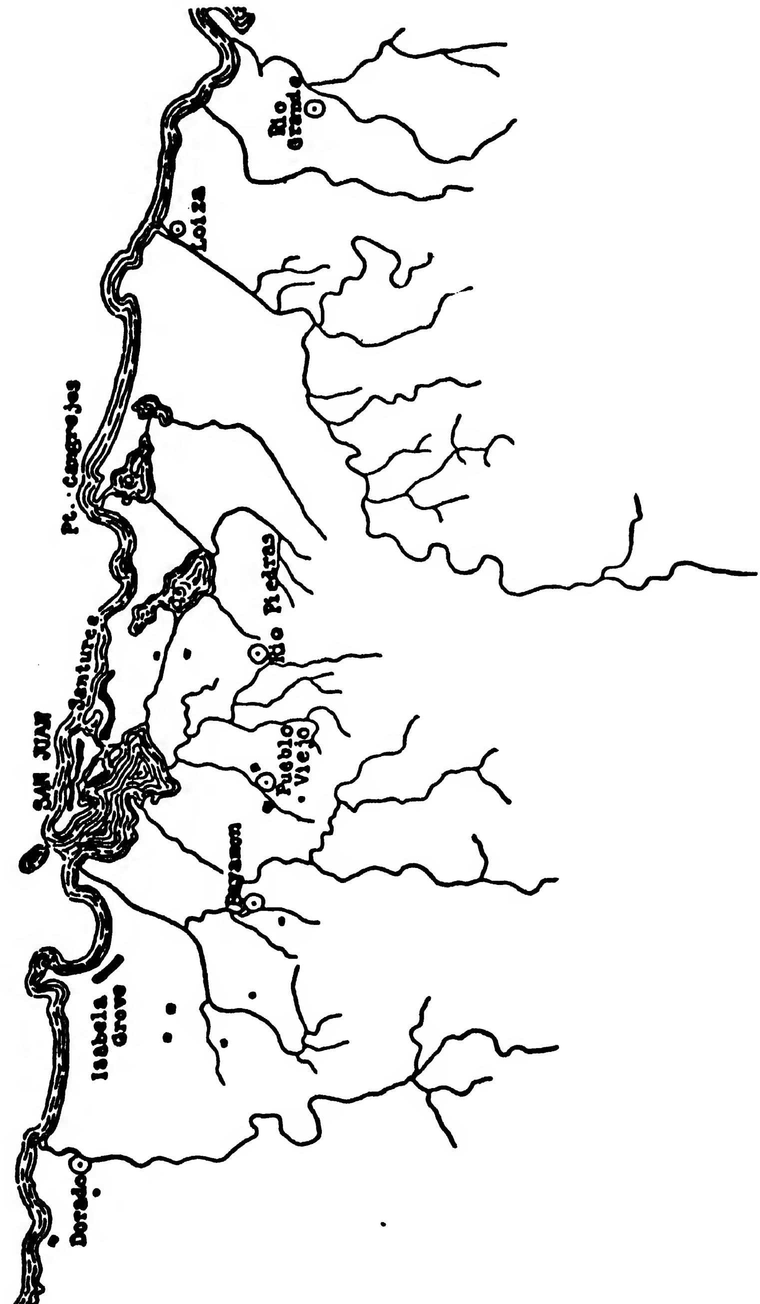
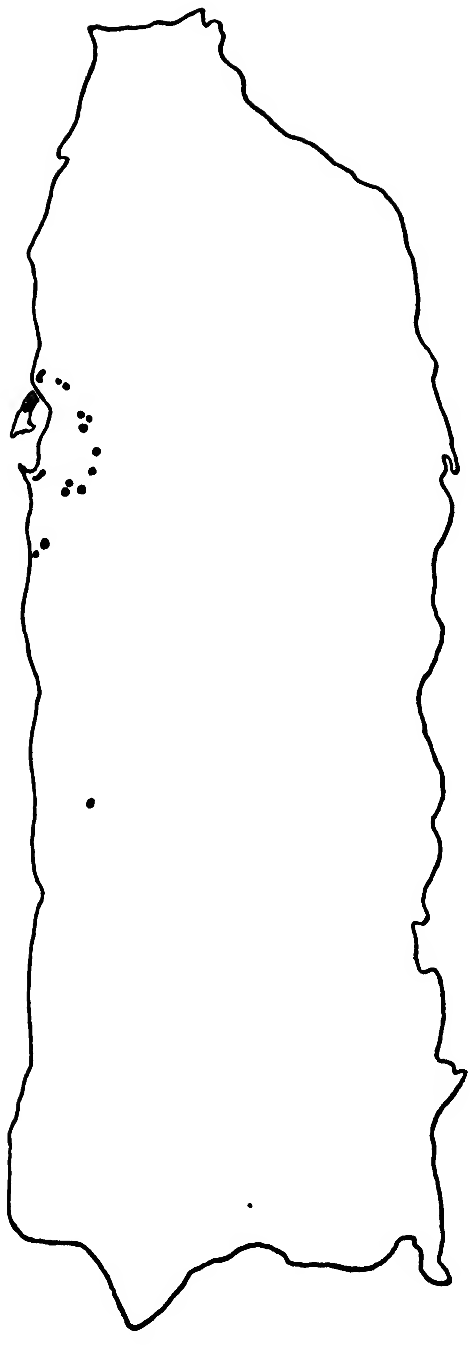

Rio Grande
Loiza
Pt. Cangrejos
Rio Piedras
Santurce
SAN JUAN
Pueblo Viejo
Bayamon
Isabela Grove
Dorado

PLATE XVIII.



RECENT EXPERIMENTS IN THE CONTROL OF TWO PUERTO RICAN ANTS

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The control of ants in temperate zones is a comparatively simple matter, for ants there affect man directly mostly as household pests (and to only a minor degree in decreasing crop production), and against them in houses, simple and familiar methods of control have long been in use. As a natural consequence, comparatively little attention has been given to devising any new remedies. When a foreign ant, such as the so-called Argentine Ant, with most injurious habits, and not susceptible to the time-worn and "old reliable" methods of control, does become established, adequate study of its habits and individual preferences eventually shows how it may be controlled (**1**). A comparable result may be confidently anticipated in the tropics when the importance of the various economic species is recognized and the control of each is considered a separate and distinct problem. To be sure, numerous species of ants are household pests in the tropics, but some of the same, or often quite different species are of much greater importance as factors in affecting crop production. Their habits are often, in the main, similar to those of the ants of temperate zones, but in other cases are so completely different that they are only slightly inconvenienced if the methods of control so successfully used elsewhere against other species are tried out against them. Even, and in many cases especially, the Argentine Ant syrup—devised for use against this one ant and against no other—is a failure. The fundamental difficulty is that the most diverse of tropical ants are lumped together as one kind of insect, against which one standardized method of control should be effective. As a matter of fact, they are as different and individual in their habits as tho they belonged to different orders of insects. In Puerto Rico, the country people speak of and recognize several kinds of ants, and most of them know at least the following:

1. "albaricoque", *Tapinoma melanocephala* F.
2. "albayalde", *Wasmannia auropunctata* Roger.
3. "barraco", *Odontomachus haematodes* L.
4. "hormiga brava", *Solenopsis geminata* F.
5. "hormiga loca", *Prenolepsis longicornis* Latreille.
6. "hormiguilla", *Myrmelachista ambigua ramulorum* Wheeler.

To be sure, this is hardly more than a tenth of the total number of kinds of ants found here by Dr. Wheeler (2), but it includes all the common and distinctive species. That so many can be distinguished by an ordinary person is the surest indication that in their activities, or some other factor affecting man, they are essentially and fundamentally different.

Of all the species of ants present in Puerto Rico, the fire ant or "hormiga brava" is by far the most abundant generally, and affects man in the most varied ways. It is a pest in citrus groves and in pineapple plantations, and as these crops earliest received attention at the newly organized Agricultural Experiment Station at Mayagüez, the first economic study of the hormiga brava in Puerto Rico was conducted there (3). The slender circular (undated and with not even the place of publication noted) detailing the results of these studies has long been out of print. Because the method of control there given is today just as effective and practical as when first devised, it is here reprinted without change. It should be noted, however, that the common mealybug of pineapples, in Puerto Rico as elsewhere, is *Pseudococcus brevipes* Cockerell.

PORTO RICO AGRICULTURAL EXPERIMENT STATION

D. W. MAY, *Special Agent in Charge*

CIRCULAR NO. 7

CONTROL OF THE BROWN ANT
(*Solenopsis geminata, Fab.*)
and the
MEALY BUG
(*Pseudococcus citri, Risso*)

IN PINEAPPLE PLANTATIONS

The brown ant and the mealy bug are at present doing considerable damage to pineapples. The brown ant alone seldom does any real damage; it is when it accompanies the mealy bug that the destructive work begins.

These ants are always found where mealy bugs are present, not eating the plants themselves, but attending the mealy bugs, carrying them from place to place, distributing them over the new leaves, and, as a reward for their labor, obtaining the honey dew which is secreted by the mealy bug. A few cases have been observed where the mealy bugs were so numerous that they irritated the fruit to such an extent that the juice began to run. This was eaten by the ants and they then continued to eat into the fruit, puncturing it and getting more of the juice. Some of these fruits were packed and shipped to New York, while others were kept at the Station. The fruits shipped to New York broke down and were unsalable. On examining a number of fruits after ten days, which is equal to the time elapsed in shipping, it was found that a fungus had gained entrance through these minute holes, causing the pines to break down.

LOCATION OF ANTS' NESTS

Ants generally attack the outer rows of plants first, gradually working in towards the center of the patch. The outer rows and borders of a pineapple field should be carefully watched and all ant hills destroyed as soon as found.

The nests of the brown ant are found in almost any part of the pineapple plantation; around the base of the plants, under the roots between the rows and in the paths, but more often they are found around the roots of the plant. When the nest is under the plant, the ants often carry sand and earth up into the plants and build other nests in leaf axils.

Upon examining these nests a great many mealy bugs are to be found. These are tended by the ants and distributed by them over the young leaves, and from plant to plant.

Before the flower stalk develops, the mealy bugs are found on the leaves around the center of the plant, especially between young leaves which are very close together, as these afford better protection for the insect. On fruiting plants, the mealy bugs are found on the flower stalk, also around the base of the fruit, and very often on the fruit itself.

NOTES ON SPRAYING

Kerosene emulsion, with a small amount of crude carbolic acid has given the most satisfactory results in killing the mealy bugs and the ants. Extensive tests with crude oil sprays have been made but none of these emulsions have proved as effective in killing the ants and mealy bugs as emulsions made with a low grade of kerosene oil and crude carbolic acid.

Formula for Spraying Pineapples.

2 gallons of kerosene
1 pint of crude carbolic acid
½ pound Fairbank's Blue Cloud Soap, or Good Caustic Potash Soap.
1 gallon of water

First put the oil in a barrel. Then dissolve the soap in the water with the carbolic acid by boiling, and pour into the barrel. Mix the whole with a spray pump by pumping back into the barrel for half an hour. A creamy mixture will be obtained which should hold up for from two to three weeks. This is to be used as a stock emulsion. Use 1 gallon of stock emulsion to 8 gallons of water.

ANTS' NESTS UNDER PLANTS

When there is an ants' nest directly under and around the plant, it is best to spray the nest first. If this is not done, the first drops of spray falling from the plant will startle the ants and they will immediately begin to move out carrying their young with them, and in this way many will escape the spray. When the nest is large, it is suggested that it be sprayed and then broken up with the nozzle forcing the spray down into the nest. In this way few ants have a chance to escape, but, as many of them are away feeding at the time, it is necessary to spray again the next day when the remaining ants will be busy building a new nest. This new nest is built close to the old one. All nests in the paths and between banks should be treated in the above manner.

An extension rod about three feet long is very handy in spraying pines, and an elbow is also advised so that the spray may readily be turned down between the leaves.

There is a time in the life of the pineapple plant when it should not be sprayed, that is, when the fruit bud is forming. At this time the bud is very delicate and any spray which will kill the mealy bug or ant, is liable to injure the bud. The spray does not always kill the blossom, but the fruit may develop without a top or crown. Fruits which have formed and stopped blossoming may be sprayed, but great care should be taken.

As the mealy bug is found between the central or the new leaves of the pine, a nozzle which throws a fine but forcible spray is ideal. The nozzle should not throw a spray which spreads over a great area, but one which can be directed down between the leaves, reaching a depth of eight inches and not spreading over an area of more than four inches. It is not the amount of spray that kills, but the spray that hits the mealy bug with force enough to remove the mealy coat and thus saturate the skin of the insect.

As the heart leaves of a pineapple are very small and lay very close to the next set of leaves, it is recommended that the nozzle be placed against one of the second row of leaves, thus spraying the outside of the heart leaf and the inside of the next leaf at the sale time. There are generally three sets of these leaves which come together in the above manner. It may seem impracticable to spray in this way, but, if the nozzle is not inserted between the heart leaves, the mealy bug will not be killed. To spray in this way takes a little longer than filling the crown, but after one has become accustomed to the work, it can be done very quickly.

When pines are sprayed in this manner the emulsion runs down over the central portion of the plant, filling up the crown and gradually running down around the roots.

W. V. TOWER,
Entomologist.

Mr. Tower, continuing his observation on the hormiga brava as it affected citrus growing (4), states that on fruits, "the scars made by ants are altogether different from those produced by the wind, the former being deep-seated and caused by the insects removing some of the epidermis and eating into the fruit.

"There are several species of ants which feed upon the nectar secreted by the orange blossoms. The brown ant and the little black ant are especially fond of the nectar. These two species have been seen working in the blossoms in the early morning, sipping the nectar, and toward noon, when it has been exhausted, attacking the unopened blossoms, or young fruit. Some cases have been observed where the green calyx leaves were eaten so badly that the fruit dropped. In other cases the pistil was chewed off and the fruit never developed. Again, the brown ant sometimes cuts holes in the young fruit.

"Ants do more damage during years when there is scanty bloom or when the bloom extends over a prolonged period, as they eat the fruit when not supplied with sufficient nectar.

"Ants are always found where the white fly and the Lecanium scale are present. They attend these two insects to obtain the honey-dew secreted by them. When their supply of food is suddenly cut off, ants often attack the young, tender shoots of the orange, eating them at the point where they join the branches. They also eat young, tender leaves, and a few cases have been observed where they had cut holes in ripe fruit. Under these conditions much damage is done. They also carry sand up around the base of the trees, and when there is scant food supply they gnaw the bark of the tree where it is covered by their sand houses. Often when pineapples have been removed from between rows of orange trees ants attack the latter in great numbers, scarring the trees, eating young, tender shoots and cutting holes in the fruit.

"When they appear in this way they must be killed by spraying. The simplest and most inexpensive spray that has been used is carbolic acid soap. The following formula has been used with great success:

Water	1 quart
Soap (Good's caustic potash or whale-oil, or Fairbank's blue-cloud soap)	½ pound
Crude Carbolic Acid, 100 per cent (dark)	1 pint

"Dissolve the soap in water and add the crude carbolic acid, then add sufficient water to make two quarts. This should be used as a stock solution, using one pint of the stock to six gallons of water.

"In spraying for ants it is advisable to locate the nests and destroy the ants by spraying down into them. A second spraying is always necessary the following day, as many of the ants are away from their nests at the first spraying. In spraying large nests it is a good plan to first spray a circle around the nest and then to spray directly into it, thus making it impossible for the ants to crawl out and insuring their being killed by the emulsion."

In the following years, when the Yothers formula for making the "cold-stirred" engine oil emulsion had been generally adopted by citrus growers for the control of scale, it was found that by adding a small amount of crude carbolic acid (one pint to 25 or 50 gallons of spray, or one-half to one-quarter of 1 per cent), this oil spray could be made also toxic to ants, and for an extended period would protect the trees sprayed with it from ant attack. Numerous growers, especially those in whose groves ants were especially troublesome, came to add the crude carbolic acid as a routine practise. It must be admitted that its use was not exactly popular, for its effect is to

quickly rot the rubber gaskets and other rubber parts of the spraying apparatus coming in direct contact with the spray. In other respects, however, crude carbolic acid meets every requirement, for it is cheap, easy to apply and unquestionably effective in killing ants. In the case of many insecticides, a purer or finer (and more expensive) grade of poison is necessary if injury to the plant is to be avoided, but in the case of carbolic acid, the effectiveness resides largely in crudities present with the acid. Consequently, the dark, unpurified and cheapest grades (containing the smallest amounts of carbolic acid) are the most desirable for insecticidal purposes.

A little later, when commercial manufacturers began placing oil emulsions or "miscible oils" on the market which were equally effective in killing scale, and much easier to use because they need only to be diluted with water, many growers ceased to make up their own sprays and relied entirely on the commercial product. Some of these contained some crude carbolic acid, added by the manufacturer for ease in making the emulsion and not for any insecticidal value the substance might have, but others contained none. No stress was laid on whether the product did, or did not, contain enough crude carbolic acid to kill ants, and in general, most growers did not consider this factor in making their selection from the numerous products recommended primarily (and usually solely) for killing scales. Of course, most groves on the Island are mature and established now, and suffer less noticeable ant injury; but in nurseries and young groves ants are no less abundant or injurious than they have been formerly, and the need for a means of control is just as great as ever. Theoretically, the problem of control of hormiga brava by means of crude carbolic acid emulsion is solved; practically, from the standpoint of large growers who no longer make up their own spray concentrates, it is not.

Of the poisons which have come into more general use since the war, the one which has been used with the greatest success in ant control is thallium sulfate. Considerable newspaper publicity at the time was given to successful demonstrations in destroying ants by means of a thallium syrup, conducted in the White House by Dr. R. T. Cotton, formerly of this Station. He furnished a small amount of this expensive and most virulent poison for conducting experiments in the control of the hormiga brava in Puerto Rico. His methods (5) were followed exactly at first, using the formula of one-fourteenth of an ounce of thallium sulfate dissolved by boiling in a pint of water, to which is added a pound of sugar and three ounces of honey. A trial was made of the paraffined pill boxes which he

had found useful as containers for the syrup. These containers serve reasonably well in houses, if not disturbed by children, pets or servants, but out-of-doors in citrus groves, they quickly go to pieces. The experiments were continued with paraffined paper cups, all of one piece of tougher paper, over which a cap fits, manufactured especially for this purpuse by the Antrol Laboratories of Los Angeles. Such cups were used in all later experiments and were much more satisfactory. The experiments were conducted in the small citrus grove back of the Sub-Station building at Isabela, and in lawns and flower gardens near-by. In all cases, the ants appeared to feed on the syrup at first, but so far as one could judge, were but little affected by it, and soon learned to avoid it entirely. The results were uniformly discouraging, for in no case was even a small colony of ants completely destroyed, and no apparent impression was made on larger colonies. If the cup was placed at the entrance of the nest, the ants constructed a new entrance several feet away. If a fresh cup was placed at the new entrance, this also was deserted. One large colony in a lawn constructed six new entrances thus in succession, and while some of the ants may have been killed by the poison, no permanent reduction in their numbers was observable. If the cup was placed at the base of a citrus tree, where the ants were ascending and descending, they soon moved their line of march so as to avoid coming near the cup, and if another cup was placed in the new line of march, this also the ants soon learned to avoid. A final and definite experiment planned in the citrus grove at Isabela, laid out at the time of the experimenter's departure, appeared to be a complete success, when examined about two months later. This apparent success was entirely due, however, to the trees and nests having been sprayed by the mayordomo with crude carbolic acid emulsion a few days previous to examination. He had given up hope of the thallium syrup having any effect, and was determined to save the trees from ant injury by a method of the efficiency of which he had been convinced by demonstration on the main block of trees.

In most marked contrast of the uniform failure of thallium out of doors, the syrup was most unexpectedly successful when used in the house, and has since proved uniformly valuable in every experiment since conducted. A cup of syrup placed on the line of march of ants going from their nest to a garbage pail, food safe, bread box or refrigerator, will, within a few hours, eliminate them entirely from their chosen food, and in less than a day they will cease to visit the cup of poison syrup. Weeks later they may again return, but putting the cup out again on the line of march will disperse them more

quickly than before. The syrup is of no value when placed with or beside the food, but when several feet nearer the nest than the food, works with almost magical effect. Collapsible tubes of this syrup can be purchased locally and can be recommended to housekeepers who are not interested in the home preparation of the poison syrup.

While these experiments were being conducted, reports of the successful use of this poison syrup in the citrus groves of the Río Grande Valley of south Texas were received (6), and Mr. C. H. Behse, Jr., of the Gulf States Chemical Co. of Harlingen, Texas, came to Puerto Rico to try out some of the mixtures which had proved so successful in south Texas. His experiments in the citrus groves here were no more successful than those conducted by the writer, and as a result of their failure, he submitted additional mixtures, of varying composition, to be tested here. One of these was his standard dry pellets in a collapsible tube, another the syrup in a tube, a third a combination with dried blood, and a fourth, an unknown mixture, dark in color. All of these were placed at the base and higher up in the crotches of large citrus trees near the beach at Dorado, all trees being heavily infested with hormiga brava. After several weeks, they were replaced with fresh tubes. As the supply of tubes containing the unknown were exhausted, these were replaced with a mixture of thallium acetate and ground meat. In some cases, a possible diminution in the number of ants might be imagined on some of these trees, especially those on which the standard syrup was present, but in no case was it sufficiently marked to be considered as constituting even commercial control. After several months, additional fresh tubes and thallium acetate and meat were placed on the trees, but after the lapse of several more months, no more definite results consequent on the presence of the poison could be observed than before.

As a final conclusion to this poison experiment, to parallel a similar experiment previously conducted with the "hormiguilla", a mixture of Hamburg steak and sodium cyanide was placed at the check trees, which had not previously been treated with any poison. The action of the fresh meat on the cyanide is to cause the immediate liberation of hydrocyanic acid gas, which kills all the ants coming anywhere near the meat. Within a few minutes after application thousands of ants were killed, but some were still running about a few hours later, and when the trees were examined a few weeks later, some of the colonies appeared even larger than before. Before making a fresh application of meat and cyanide, all the loose sand at the base of the trees was brushed away, so that the meat could be placed

in close contact with the base of the tree and no ants descending to their nest could avoid it. Within a few minutes thousands of ants were killed, and by moving the bits of meat about so that they rested beneath runways not at first covered, all the ants in sight were soon killed. Brushing away still more of the sand and exposing some of the ants in the nest, these also were quickly killed by placing the meat in their midst. As an indication of how rapid was the action of the poison when properly applied, the case should be mentioned of one tree which had been densely over-run with hormiga brava tending cottony cushion scale. After a few minutes, it was so completely freed of ants that it could be ascended with safety, without danger of being bitten. Meat unmixed with cyanide is very attractive to hormiga brava, but no case was noted of the ants attempting to eat the poisoned meat. In this respect their action was very different from that of the "hormiguilla", a slow-moving, phlegmatic ant which remains quietly in one place eating the poisoned meat until overcome by the hydrocyanic acid fumes. The action of the cyanide and the meat rapidly destroys the great majority of the foraging workers, but some remain uninjured and unaffected deep in the ground. Thus the colony is greatly weakened, but not exterminated. It is not an especially cheap or simple method of killing ants, but it was some satisfaction to see some dead ants after vainly putting out thallium mixtures for so many months. Indeed, it is no more effective than dusting the nests with calcium cyanide dust, a much simpler method of obtaining the same result: the immediate destruction of the great majority of the ants.

The local agency handling the thallium tubes manufactured by Mr. Behse's company reported one rather considerable sale of them to a citrus grower near Barceloneta. He reported that his experience with them had been most successful, and his grove was visited to determine, if possible, the cause of his success. The tubes had been placed in a young grove after the ground between the trees had been thoroly cultivated in preparation for growing vegetables, and after the young trees had been thoroly sprayed, so that most of them were at least commercially free of scale. It is hardly surprising, therefore that after nine-tenths of the ant nests had been broken up by plowing and cultivation, and the main source of food for the ants (the honey dew from the soft scales on the citrus trees) removed, the few survivors had been destroyed by the poison bait. In every case where all the soft scales on a tree had not been killed by spraying, it was invariably heavily infested with ants, indicating that the successful results claimed for the poison were in reality largely due to starvation.

The thallium tubes may be of some value in carefully cultivated and sprayed young groves, but they are really a minor factor in ant control. Even better results might much more easily and cheaply be attained by adding the requisite amount of crude carbolic acid to the oil emulsion spray used to kill the scale.

The "hormiguilla" or coffee shade tree ant, ***Myrmelachista ambigua ramulorum*** Wheeler, is a small ant with reddish-yellow thorax and blue-black head and abdomen that "nests in populous colonies in the hollow twigs of trees, especially the sea-grape and "torchuelo" (**2**), but in coffee groves it nests in the older guaba or guamá (*Inga vera* and *Inga laurina*) trees, and when these are heavily infested, it also attacks the coffee trees. The ants eat out irregular longitudinal tunnels in the main trunk and branches of the trees and seldom live in colonies in dead wood. In some compartments of their tunnels they rear their young, in others they care for mealbugs, *Pseudococcus citri* Risso, or the peculiar pink fleshy scale insects, *Crytostigma inquilina* Newstead, that suck sap from the tree and secrete a honey-dew which is very attractive to the ants. The most noticeable outward indication that coffee trees show of their being infested with the hormiguilla is a peculiar swollen, warty growth of bark where the lateral branches join the main trunk. The tunnels of the hormiguilla are discontinuous and seldom of uniform size. Parts of the infested branches will be entirely uninjured, while in other places the tunnels will be so broad as to greatly weaken the trees, so that they are easily broken in storms or when the berries are being picked. The scale insects and the mealybugs which the ants care for and largely depend on for food, obtain their nourishment from the sap of the tree, and even a light infestation of the hormiguilla reduces the vitality of the coffee trees so that they produce only small crops. A heavy infestation kills the top branches, and very rarely the entire tree is killed. Most growers consider the hormiguilla the most serious and destructive insect pest in their groves.

The old guaba and guamá trees in a coffee grove are the centers from which the ants go out to establish other colonies in the coffee trees, and the destruction of these old trees and the planting of new shade will eliminate the hormiguilla for several years. The smoke of charcoal fires has no effect on the hormiguilla, except, naturally, that many ants perish when the trees in which they have been living are cut down and used in making charcoal.

But the cutting down of these old shade trees is not always practicable, and in such cases the number of hormiguilla nesting in them can be very considerably reduced by poisoning them. Because the

hormiguilla has no one main nest, and because most of the ants remain within their tunnels in the tree most of the time, comparatively few are killed by a spray of carbolic acid emulsion, or by dusting with calcium cyanide. Altho the ants feed on the sweet excrement of their mealybugs and scale insects, they are not attracted by poisoned sweet substances prepared by man for their destruction. The Argentine Ant syrup they ignore entirely. But it was observed that they are attracted by dead insects and bird droppings that happen to occur on the leaves of infested trees, and when bits of meat, fish or cheese are placed on the trees, these are soon surrounded by ants feeding upon them. After numerous experiments with various kinds of poisons, it was discovered that potassium or sodium cyanide, powdered and mixed with meat would attract and kill the hormiguilla. The ants stay within their tunnels when it is rainy, and can not be enticed out even by fresh meat, and no poisoning should be attempted except during dry weather. At such times, a mixture of one pound of meat with two ounces of powdered sodium cyanide may be applied in the form of little shelves beneath the places where the ants are abundant, where the bark is rough or there are cuts in it to which the plastic mixture will adhere. The moisture and acid of the meat reacts on the poison to set free a very poisonous gas, hydrocyanic acid, which is lighter than air, and therefore kills only the ants that are above the little shelf. The gas acts on the ants promptly, but if they fall to the ground, they will eventually recover from its effects. But if the meat is placed in the form of a shelf so that the ants overcome by the poisonous fumes do not fall off but remain within its influence for even a few minutes longer, they will be dead.

During the years 1923–24 extensive experiments in this method of destroying the hormiguilla were conducted. Three applications of poisoned meat, at intervals of two or three days, killed practically all of the ants on a rather lightly infested guamá tree near Mayagüez. On three other trees, much more heavily infested, the same number of applications killed many more ants, but considerable numbers survived. An experiment was started in November and continued throughout the winter and spring on a large jagüey tree in the Ciales valley near Manatí, which was heavily infested with hormiguilla. In all, eight applications (Nov. 5, Dec. 13, Dec. 28, Jan. 14, March 3, March 17, April 3 and April 8) of the poisoned meat were made, using a pound of meat and one or two ounces of poison for each application. Altho enormous numbers of ants were killed, and at each successive application the decrease in the ant population was noticeable, yet the applications were made at too great intervals

for maximum effectiveness, and the tree was still somewhat infested at the time the last application was made.

As the experiment was continued, certain refinements of methods were adopted. By smearing the very smallest amount of unpoisoned meat about half an inch above the point where the poisoned meat shelf was to be placed, the ants could be induced to collect there and be overcome by the fumes of poison rising from the shelf beneath. The hydrocyanic acid gas is generated in the greatest quantity in the first few minutes after the cyanide is mixed with the meat, and is most effective the more promptly it can be applied to the tree. It continues to be generated for several days, but in much smaller amounts after the first few hours. If the meat does not dry out, it is effective for a considerable period, and has been observed to kill ants five hours after application. Also, the poisoned meat begins to harden soon after mixing, and the more promptly it can be applied, the more easily it can be shaped into a shelf, and the better it sticks. Thus, during the later experiments, only half a pound of meat and an ounce of poison were mixed at a time, the second half pound being mixed and applied some time later. From one shelf, the dead ants were collected and found to number 2,400. If all the shelves were as favorably located, and killing with this efficiency, the total number of ants killed on a large tree would be enormous. The ants killed should weigh almost as much as the meat, for their dead bodies pile up on the shelves so as to bulk larger than the shelves themselves, when not blown away by the wind.

This method of killing hormiguilla, despite the enormous numbers of ants killed, does not destroy the colony, and merely reduces the infestation. But their numbers can be so greatly lessened that old guaba and guamá trees which can not readily be removed, may safely be retained in the grove, if repeated applications of poisoned meat are made at intervals of a few days during dry weather. In practise, the use of ground meat and cyanide is too expensive and troublesome, and is not sufficiently effective to be whole-heartedly recommended to coffee growers generally. So far as known, it has never been used commercially, and, indeed the need for any artificial method of destroying the coffee shade tree ant was largely obviated, temporarily at least, by the hurricane of San Felipe, which blew down most of the older and larger shade trees in the coffee groves of the Island.

As the young shade trees grow larger however, they begin to harbor injurious numbers of hormiguilla, and eventually the problem of their economical control will again become pressing. Thus, at the same time that experiments were being conducted with thallium sul-

fate against hormiga brava, parallel ones were started with this substance against the hormiguilla. A guamá tree, well infested with the hormiguilla was found only a short distance from the Sub-Station at Isabela, and preliminary experiments were commenced on it. The sulfate of thallium is very sparingly soluble in water, but it was hoped that a small amount of the finest powder mixed with ground fresh meat might dissolve. Judging by the results of the first experiment, none did so, for no apparent diminution was noted in the size of the colony after several weeks. When the poisoned meat was first placed on the tree, the ants swarmed about in their characteristic manner, devouring it greedily, but picking out and discarding any particle of the poison, minute to us but enormous to the ant, found mixed with meat. As the obvious cause of the failure of this experiment was that the poison was not in solution, a small amount of powder was cooked up with Campbell's mock turtle soup, and boiled until it was a thick paste. The ants were not the least bit deceived by the pseudo-meaty flavor of this mixture, and paid absolutely no attention to it.

Shortly after the ignominious failure of these experiments, Mr. Behse suggested the use of one of the more soluble compounds of thallium, stating that, in his experience, vastly more than the amount of thallium acetate necessary to kill ants would dissolve readily in the amount of liquid present in fresh beef. For his own work he had not even considered this poison as being commercially practical, on account of its cost, but suggested that the small amount necessary for carrying out the preliminary experiments might be obtained from the Ore and Chemical Corp., 40 Rector St., New York City. Eventually, after some delay, for the poison had to be specially ordered and imported from the factory in Germany, an ample amount for experimentation was received thru the courtesy of this company. In the meantime, however, the experimenter had been transferred to Río Piedras, in the near vicinity of which no hormiguilla infested trees are available for conducting experiments. After vainly examining numerous guaba and guamá trees, it was finally decided to use the historic jagüey tree in the Ciales valley near Manatí, for, in the course of the years which had elapsed since the close of the experiments with meat and cyanide on this tree, the colonies of hormiguilla had again become populous.

The first tentative application of a freshly prepared mixture of about a third of a pound of hamburger steak and two or three grams of thallium acetate on the trunk of this jagüey tree was made on August 4, 1932. The ants swarmed out to feed on the meat with

their accustomed eagerness, and apparently were unaware that it had been mixed with a most powerful poison. To test their perception of the presence of the poison, an additional amount was dusted on the level portion of one bit of meat where they were feeding, and even while it was dissolving in the meat juices, the ants continued to eat.

At the time the application was made, the sun was shining brightly, and the trunk of the tree was dry, but a few hours later the sky became overcast, and during the afternoon and following night several showers fell. None was of sufficient size or duration to get more than a part of the trunk of the tree wet, and when examination was made the next day at noon, it was found that one effect of the rain had been to keep the meat from drying out, and many ants were still feeding on it. Some of the bits of meat had been fashioned into shelves, because the experimenter had become accustomed to moulding them into this shape when cyanide was mixed with the meat, and on these shelves, numerous dead ants were to be seen.

The second application of half a pound of steak and five ounces of thallium acetate was made three weeks later on this tree, in many cases on top of the dry remains of the meat applied previously, but also further around its enormous trunk. The ants came to the meat eagerly, but not in such large numbers on the part of the tree previously treated. A third application was made between two and three weeks later, ants still being numerous on all parts of the trunk. Ten days later a fourth application was made, and it was then for the first time noted that the ants were not especially numerous, and seemed not especially eager to eat the meat. The hurricane of San Ciprián occurred on September 26–27, 1932, and no opportunity to visit the jagüey tree was available until October 20th. Some of the larger branches of the tree, amounting to possibly a third or a fourth of its bulk, had been broken off by the hurricane, but the trunk was uninjured, and many of the larger branches and small twigs were intact. Very few hormiguilla were to be seen, and even when fresh, unpoisoned meat was placed on the trunk, no ants came to it. The remainder of half a pound of steak was poisoned and applied in the usual manner, mostly in new locations, but this brought out only a few ants. Of course, the hurricane by blowing away so many branches had considerably decreased the ant population of the tree, but this decrease would be only approximately in proportion to the amount of the branches so removed. By comparison with the number of ants present two months previously, a conservative estimate was that

99 per cent of them were gone, and most of this was undoubtedly due to the thallium acetate.

The tree was later examined on November 30th, and while the trunk was still entirely free from ants, a considerable number could be found in the tips of twigs, in the part of the tree most distant from the trunk, where the poison had been applied. That the ants should have thus persisted in the tree indicates the difficult nature of the problem of hormiguilla control, for the ant population of a large tree consists, not of a single large colony, but of a large number of separate colonies, not sharply delimited, but each having communication only with its immediate neighbors. All the needs of the members of these colonies are supplied by resources close at hand, and apparently those inhabiting the twigs have little or no intercourse with those on the trunk. Nevertheless, the experiment indicates that commercial control of the hormiguilla: reducing the number of these ants present on the shade trees to such an extent that they do not overflow to the surrounding coffee trees, is now in sight.

How practical control by means of a proteid mixed with thallium acetate will be, how it will work out in practise in coffee groves, and how long such control will be effective, are points yet to be determined. Experiments were promptly started in coffee groves, but the Station at Río Piedras is most unfortunately located for initiating, continuing and observing such work in coffee groves, and the actual operation has necessarily been turned over to the Agents of the Extension Service who are located in coffee regions.

The three most important factors in determining the adoption of any method of insect control are: (1) non-injuriousness to host, (2) effectiveness, and (3) cost. In thus analyzing the value of the thallium acetate meat bait mixture for hormiguilla control, it should be noted that thallium is poisonous to vegetation as well as to animal life, but in the small amounts used, no effect at all has been noted either on the trees on which it was applied, or on the surrounding vegetation. Effectiveness appears to be close to perfection, altho it is yet much too early to say anything about permanence. The third factor—cost—is unquestionably high in the present stage of development of this method of control, but may be very considerably reduced as cheaper and more desirable substitutes for fresh hamburger steak, and simpler methods of application are devised. The poison itself is admitted expensive, but such minute quantities are needed that it is not the major item in total cost. Indeed, in these experiments, the steak at 18 cents a pound was more

expensive than the thallium that was mixed with it. Thallium sulfate is now extensively used in California and Hawaii in rodent control, and in south Texas in ant control, and it is only a third cheaper than the acetate. The present price of thallium acetate is something under $11 per pound in hundred pound lots, or a little over two cents a gram. Up to the present there has been no commercial demand for it, but if other uses for it are developed, this price may be somewhat reduced. It is quite possible that even smaller amounts per treatment would be effective if the poison could be more thoroly mixed with the bait. A uniform mixture would be ensured by the use of a meat jelly, semisolid at ordinary temperatures, but liquid at the higher temperature at which the solution of the poison is added. By the addition of other substances, the jelly could be given other desirable qualities: greater adhesiveness and less tendency to dry out rapidly after application, or to spoil if not used immediately.

SUMMARY

1. Under local conditions, experiments have indicated little value for thallium compounds and mixtures against the hormiga brava, *Solenopsis geminata* F., out-of-doors. In-doors, the thallium sulfate syrup has been just as uniformly successful as out-of-doors it is a failure. An emulsion of crude carbolic acid, either alone or mixed with kerosene emulsion or the engine oil emulsion sprays used for scale control, is still the cheapest and most effective insecticide to use against this ant in citrus groves, pineapple plantings and vegetable gardens.

2. Against the hormiguilla, *Myrmelachista ambigua ramulorum* Wheeler, a bait consisting of ground meat and thallium acetate is very effective, and gives promise of being adopted commercially when cheaper and simpler methods of application are devised.

BIBLIOGRAPHY

1. **Barber, E. R.,** "The Argentine Ant: Distribution and Control in the United States". U. S. Dept. Agr. Bull. **377**, pp. 23, fig. 4, table 1. Washington, August 18, 1916.

2. **Wheeler, Wm. M.,** "The Ants of Porto Rico and the Virgin Islands". Bull. Amer. Mus. Nat. Hist., **24**, (Art. 6): 117–150, fig. 4, pl. 2. New York, 1908.

3. **Tower, W. V.,** "Control of the Brown Ant (*Solenopsis geminata, Fab.*) and the Mealy Bug (*Pseudococcus citri, Risso*) in

Pineapple Plantations. Porto Rico Agr. Expt. Sta. Circ. No. **7**, pp. 3. (Mayagüez, 1908).

4. **Tower, W. V.**, "Insects Injurious to Citrus Fruits and Methods for Combating Them". Porto Rico Agr. Expt. Sta. Bull. No. **10**, pp. 35, pl. 3, many refs. Washington, May 8, 1911.

5. **Cotton, R. T. & Ellington, G. W.**, "A Simple and Effective Ant Trap for Household Use". Jour Ec. Ent., Vol. 23 (2), 463–464, fig. 1. April 1930.

6. **Clark, S. W.**, "The Control of Fire Ants in the Lower Río Grande Valley". Texas Agr. Expt. Sta. Bull. 435, pp. 12, fig. 4, tables 4, ref. 5. November, 1931.

THE LIMA BEAN POD-BORER CATERPILLARS OF PUERTO RICO

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The three species of pod-boring caterpillars which attack lima beans in Puerto Rico constitute the greatest obstacle to the profitable production of this crop. Thus, an economic study of these caterpillars has been one of the main entomological projects at the Isabela Sub-Station ever since lima beans were planted there. Careful and detailed observations were made there on beans planted in the late spring of 1931, to determine the relative abundance of the caterpillars in different varieties of beans. On beans planted in the fall of 1931, comparable observations were made on their relative abundance in fields sprayed with Bordeaux mixture and magnesium arsenate, and in fields that were not sprayed at all. On beans planted in the spring of 1932, observations were made on sprayed and unsprayed beans, and on proximity to alternate hosts of the caterpillars. In an extension of this spraying and alternate host experiment, to which was added treatments with nicotine and pyrethrum, on beans planted late in the fall of 1932, final results have just been obtained. As the net result of these observations and experiments, it can now be definitely stated that no method of control of these pests is known. Indeed, all those suggested as likely to result in at least partial control are found by experiment to be valueless. Before considering the experimental evidence in detail, however, it may be desirable to give a general discussion of the insects, and especially of distinguishing characters of the three species of caterpillars and their habits as affecting the possibility of control by any of the means at present in common use.

The term "pod-borer" refers to the habit of these caterpillars of entering the pod when they are very small, and thereafter feeding entirely within the pod, remaining there thruout their larval existence, and sometimes pupating there. The female moths lay their eggs singly on the flower sprays, and the young caterpillars on hatching feed on any of the floral parts. Many of the buds which drop, some of the flowers which drop without setting pods, and most of the young pods which drop, fall from the vine because they have been more or less injured by the feeding of these small caterpillars. The

initial losses caused by these caterpillars are especially obvious at the beginning of the crop, when the ground under the vines will be strewn with buds, flowers and young pods which have served as food for the young caterpillars.

When the pods get to be a little larger and firmer, however, they do not fall from the vine when one of these caterpillars begins to feed, but are thick enough so that the caterpillar burrows right up inside of the pod. As the caterpillar continues to feed inside, and the pod continues to grow, a callus is formed where the caterpillar burrowed in, effectively closing and entirely concealing the point of entrance. So far as one can see by looking at the outside, the pod is perfect. Yet actually the caterpillar continues to feed inside, sometimes confining its activities to only one bean, altho often it chews into two or even three. While the caterpillar is still actively feeding and growing, ordinarily there is no external indication of its presence, but by the time that it approaches full size, its excrement has begun to rot and show thru the pod walls. Thus the infested pod is ruined from the standpoint of marketing, and is discarded when the beans are being sorted for shipment.

All of these injuries mentioned tend to reduce the total production. Quality is also affected, however, when pods ready for shipment contain small caterpillars, for these caterpillars continue to feed and grow while the beans are en route to market. Even if their presence is not apparent when the green beans are sold, the ultimate consumer preparing the beans for cooking is disgusted to discover that they are wormy, and is prejudiced against buying green lima beans in the pod again. Of course no one individual caterpillar can possibly cause all of these described types of injury, but different individuals of each kind of caterpillar cause each one of all these types of injury.

From the standpoint of extensive distribution and of quarantine restrictions at present in force, *Maruca testulalis* Geyer, a Pyralid-Pyraustinid caterpillar, is of the greatest importance. It is present in Japan and many other regions of the old world, but only in Cuba and Puerto Rico of the new world, and specifically not in the United States. For that reason, since July 1, 1925, no beans in the pod can be exported from the West Indies to the United States, except during the winter, and only under special permit and inspection, thus to a considerable extent limiting production in the West Indies. Incidentally, these restriction have been responsible for an intensive study of this insect in Cuba, where it is the most common pod-boring caterpillar. In Puerto Rico, *Maruca* is of only minor importance,

not because it is less abundant than in Cuba, but because two other species are so much more abundant and cause much heavier losses.

All the general statements made regarding pod-borer caterpillars do not apply exactly to *Maruca,* for the caterpillars after burrowing into the pod, have the habit of keeping an exit open to the outside, thru which to void their excrement. This habit is also of value to the bean grower, for he is thus able to make sure of all infested pods, and eliminate them as culls when green beans are being prepared for shipment for distant markets. Of course it does not lessen the injury caused by the caterpillars, but at least the shipper can be sure that

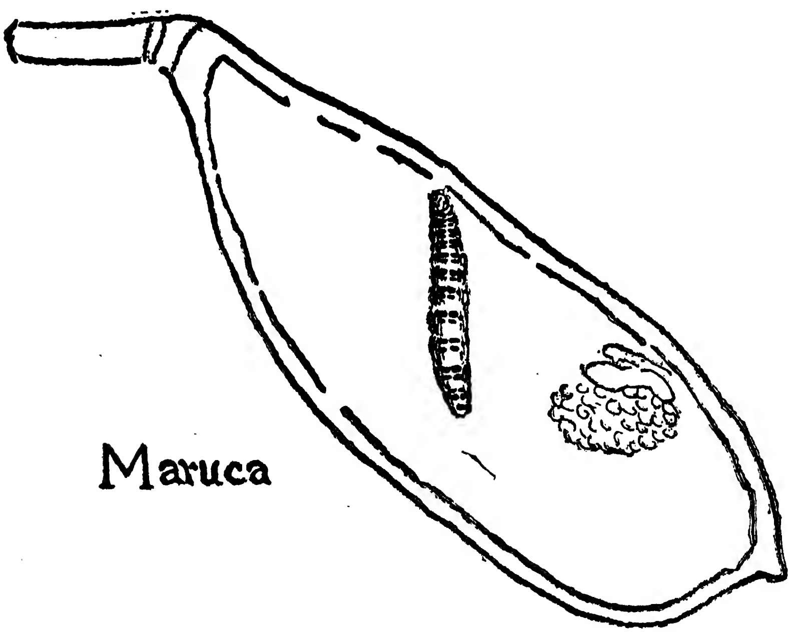

FIG. 1. Caterpillar of *Maruca testulalis* Geyer in small pod in which it has eaten all the beans. About twice natural size. (Original).

he is not sending out infested pods which will rot en route, or arrive in the kitchen of the housewife wormy and disgusting.

Maruca caterpillars are generally of a creamy white, and can most readily be distinguished by their spotted appearance, for they have four large black or dark grey spots on the back of nearly every segment. Sometimes the spots are not very dark, but usually they are quite distinct, and coupled with the presence of a frass-disposal hole to the outside of the pod, one can usually identify the caterpillar without difficulty. When fully grown, the caterpillars are two-thirds

of an inch long, and are then about to leave the pod where they have been feeding. They spin cocoons almost anywhere outside of the pod, or at times, even inside a dry pod, but usually their cocoons are found between pods, or on bean hampers, or in trash on the ground, and only rarely at any great depth in the ground itself. The moth is very active, and when not flying about, stands with wings outspread and all ready to go. The forewings are chocolate brown, with a large white triangular spot on the front margin, and the hind wings are silvery white with a brown spot at the corner more distant from the body.

Parasites of the caterpillar have been reared in Cuba, but are not abundant, and are a very minor factor in checking the numbers

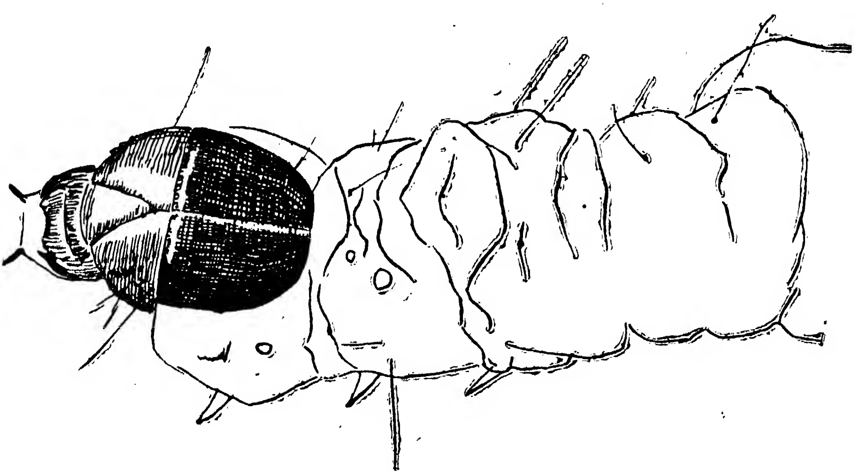

FIG. 2. Head and fore part of body of the caterpillar of *Fundella cistipennis* Dyar. About twenty times natural size. (Original).

of the pest. Spraying with Bordeaux has no effect on the amount of infestation, and about all that growers can do is to hand kill all the caterpillars that crawl out of the pods while they are being packed for shipment, and to destroy the culls. Experiments in Cuba have shown that the caterpillars in the pods can be killed by maintaining the pods for an hour in moist atmosphere of 44° to 46° C., or by fumigating with carbon bisulfid for two or three hours. By such means, wormy beans may be prepared to meet quarantine restrictions, and shipped to northern markets if a temporary scarcity of fresh beans warrants. From the standpoint of maintaining standards, however, a more careful inspection and culling out of all worm-in-

fested pods is much more satisfactory, even tho in special instances it may not be so immediately profitable.

The two more abundant species of pod-boring caterpillars in Puerto Rico are: *Etiella zinckenella* Treitschke (known in California as *E. schisticolor* Zeller) and *Fundella cistipennis* Dyar. Both insects belong to the same sub-family of the Pyralidae: Phycitinae, and in their larval stage are almost indistinguishable. Yet obvious differences do exist, and in Puerto Rico one caterpillar attacks lima beans only during the winter time, when they are being shipped to northern markets, while the other occurs in abundance only during the spring, summer and fall, when no shipments can be made on account of quarantine restrictions, and thus from the standpoint of the export grower is not an economic pest at all. In their earlier

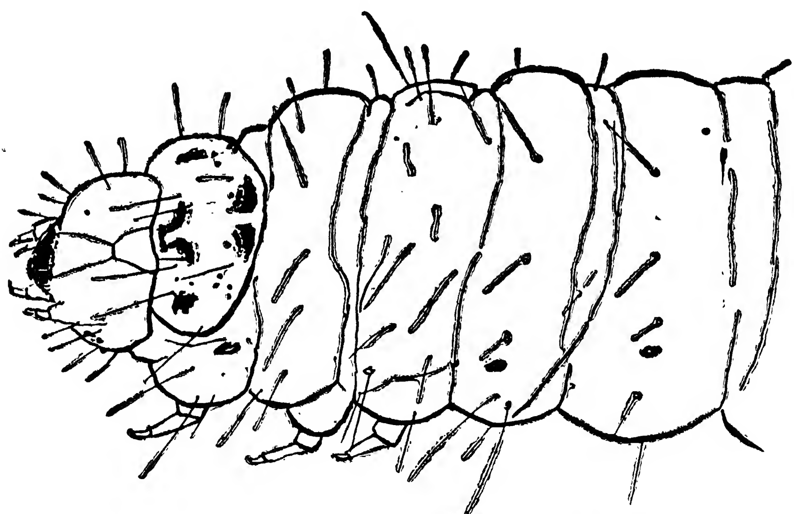

FIG. 3. Head and fore part of body of the caterpillar of *Etiella zinckenella* Treit., showing pattern on thoracic shield. About twenty times natural size. (Original).

instars, the caterpillars are indistinguishable by any gross structure, color or marking, both being light green in color, with a dark brown or black head and thoracic shield. In the last instar, many of the caterpillars as they approach full size become purplish above, altho others (of both species) become more yellowish and creamily opalescent. Both are cylindrical in shape and in size approach *Maruca,* two-thirds of an inch long.

Their heads (in both species) vary in depth of coloration from a light yellow to a dark brown, but the thoracic shield, just back of the

head, furnishes the clue to specific identification. The thoracic shield of *Fundella cistipennis* is of the same color as the head, or possibly a little darker, unmarked, or with the markings scarcely visible because of the dark color of the entire shield, or with the markings distinct but vaguely outlined and of a variable pattern. By contrast, the thoracic shield of *Etiella zinckenella* is invariably opalescent greenish-yellow, marked with a very definite pattern in black; two confluent crescents in the center forward, two broader ones to the rear, and a mark on each side, together with several pairs of small black spots, the four larger anterior marks being in sharply sculptured depressions. This sounds complicated, but, in practise, after one has seen both kinds of caterpillars at the same time and made the comparison, the difference is thereafter unmistakable.

Under normal conditions, the tough, grey cocoons of both species of caterpillars are made at a considerable depth in the soil, those of *Etiella* at a considerably greater depth than those of *Fundella,* but not in hampers or in trash in the surface of the ground as are those of *Maruca.* Adults emerge within a couple of weeks.

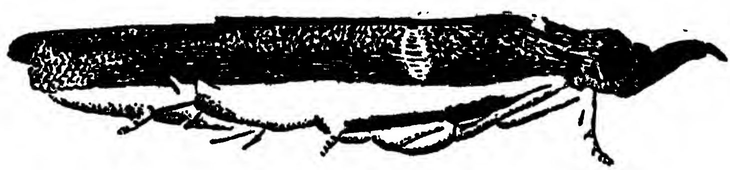

Fig. 4. Moth of *Etiella zinckenella* Treit. About eight times natural size. (Original).

The adult moths of both species when at rest keep their wings tightly folded around their abdomen, very different from the outspread wings of *Maruca,* apparently always just about to fly away. Otherwise than in the manner of holding their wings while at rest, the two species are not similar in appearance, for the forewings of *Etiella* are broadly margined with silvery white, these margins blending with the white of the legs and abdomen when the moth is at rest. Its large palpi stick out like a beak in front. The moth of *Fundella cistipennis* is of a characterless, inconspicuous greyish-brown, with no marked or well-defined pattern on the wings, but with the interesting habit of often keeping the ends of its antennae underneath its folded wings.

As regards other hosts than lima beans, the months show a most surprising difference in those on which they oviposit. During warm weather, *Etiella* caterpillars, somewhat dwarfed and dried-up in ap-

pearance as compared with the plump, juicy larvae occurring in lima beans, and longitudinally striped with purple, are quite common in the pods of *Crotalaria incana*, and in no other species of this genus of plant. Observations on this selection of host plant were made independently by two entomologists in Cuba (L. Dean Christenson & S. C. Bruner), and are confirmed by observations made by the writer in Puerto Rico. On the beach at Mameyes, EVERY mature pod of several bushes of *Crotalaria incana*, observed in mid-summer, was infested. Thruout the year, *Fundella* caterpillars are to be found attacking the pods of sword beans and beach beans, *Canavalia ensiformis* and *C. maritima*, often causing much more obvious external injuries than they do to the pods of lima beans. Sometimes as many as 3 or 4 caterpillars may occur in a single pod. (See plate XIX). (*Maruca* caterpillars are also often found in sword bean pods, their abundance in this host in Puerto Rico considerably

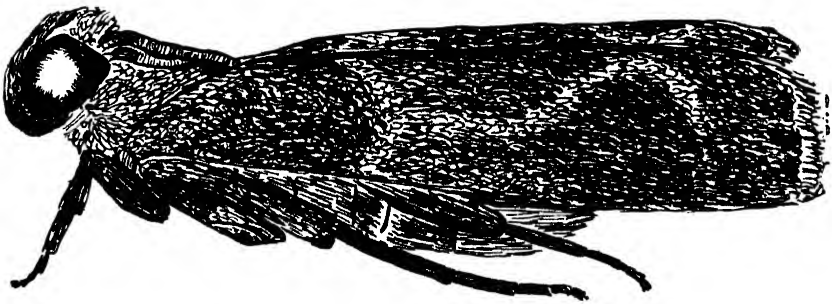

FIG. 5. Moth of *Fundella cistipennis* Dyar. About ten times natural size. (Original).

exceeding that in lima beans). *Fundella* caterpillars also burrow in the stems of cowpeas and attack the young shoots and buds.

The range of these two such similar yet divergent species overlaps only in Puerto Rico, so far as is known. *Fundella cistipennis* was originally described as *Ballovia* from Barbados, and has since been found in St. Vincent, St. Croix, Vieques, Puerto Rico and at Port-au-Prince, Haiti. *Etiella zinckenella* is of cosmopolitan distribution, being reported from many European and Asiatic localities, Colombia in South American, and from many places in the United States, altho it is an economic pest only on the Pacific coast. In the West Indies, it occurs only in Cuba and Puerto Rico.

The reported scarcity of *Etiella zinckenella* on lima beans in Cuba is presumably largely due to the fact that this crop is grown there only for export during the winter. In Puerto Rico, *Etiella* is equally

scarce during most of the shipping season, but in experimental plots of beans planted during the late spring, it becomes very abundant, often attacking from a fourth to a third of all mature pods. During the winter, when lima beans in the pod may legally be shipped to the United States, practically no *Etiella* caterpillars occur, their place being taken by smallers numbers of *Fundella,* and in lima beans grown at the higher elevations, a few *Maruca* caterpillars in addition.

The first counts made of pod-borers at Isabela will serve to indicate the prevalence of *Etiella* in the late spring, altho they were primarily intended to determine the relative infestations of the caterpillars in different varieties of beans. These observations were made in a field planted on Feb. 26, 1931, in which, after the first month, the plants were sprayed every ten days with Bordeaux mixture. The purpose of the planting was to obtain data on yields, but was also available to the writer for examination as to infestation of the pods by caterpillars. The plot was small and samples of each variety of only 25 pods were examined. At the time the examinations were commenced, the characters distinguishing the three kinds of caterpillars were not known, and it is merely presumed that most of the caterpillars observed at first were *Etiella zinckenella,* as all of them were known to be after the first four observations.

PER CENT OF INFESTATION BY POD-BORER CATERPILLARS

Average of the variety	Variety	April 30	May 6	May 16	May 20	May 28	May 30	June 5	June 11	June 12	June 19	July 2	July 20	August 28
12.......	Challenger..............	8	20	8	16	0	....	....	....	8	24	....	....	....
13.......	Carpentera..............	12	24	20	12	0	....	....	....	16	8	....	....	....
9.......	Burpee..............	30	4	4	8	0	....	....	....	....	....	....	....	....
18.......	Fordhook..............	44	32	16	8	0	....	....	....	....	....	....	....	....
9.......	Average..............	23	20	12	11	0	3	0	5	12	16	6	15	0

On another field of Challenger pole beans planted at about the same time, at Maleza, near the Agujereada light-house, the infestation by *Etiella* on June 9, 1931 was total, many pods containing two or three caterpillars. By June 30th, it had dropped to 36 per cent infestation, and was 46 per cent on July 20th. In explanation of the great difference in infestation, as compared with the field at Isabela only five or six miles away, it should be stated that infestations are usually very heavy at the beginning of the crop, dropping off rapidly when production is really started.

On the drops from lima beans observed December 1, 1931, in a field of Challenger pole beans at Isabela, sprayed weekly with Bordeaux and magnesium arsenate, the infestation was more than total,

Etiella caterpillars being fifteen times as numerous as *Maruca*, and no *Fundella* caterpillars present. Ten days later, on drops in the same field, most of the caterpillars were *Fundella*, some were *Etiella*, and a few *Maruca* were found. This field did not come into full production until the latter part of December, at which time comparison could be made with two unsprayed fields nearby of the same variety. All of these fields were in commercial production, consequently only cull pods were available for examination.

The cause of rejection varied considerably, being much more numerous in the unsprayed fields on account of spotting by *Elsinoe*, or injury by the leaf-folder caterpillar, *Lamprosema indicata* F., both of which were largely controlled in the sprayed field. Thus the frequency of infestation by pod-borers in the culls from the sprayed field appears much higher, altho it might not vary greatly from the unsprayed fields if the total crop could be sampled. Whenever possible, samples of 100 or 200 pods were examined. The records are given in the following table.

INFESTATION OF POD-BORER CATERPILLARS IN LIMA BEANS GROWN AT ISABELA, WINTER OF 1931-32

Date	Condition	*Fundella*	*Etiella*	*Maruca*	Caterpillar gone (or too small to identify)	Total
December 24	Sprayed	34	12	1		47
December 31	Unsprayed	14		1	10	25
December 31	Sprayed	14	2	2	13	31
January 6	Unsprayed	16			24	40
January 6	Sprayed	35		1	12	48
January 13	Unsprayed	5			20	25
January 13	Sprayed	9			7	16
January 20	Unsprayed	1			6	7
January 20	Sprayed	1			6	7
January 28	Unsprayed	1			7	8
January 28	Sprayed	1			6	7
February 3	Unsprayed	16				16
February 3	Sprayed	45				45
February 3	Unsprayed	9				9
February 10	Sprayed	18			37	55
February 10	Unsprayed	2			6	8
February 17	Sprayed	12		2	30	44
February 17	Unsprayed	1		1	1	3
February 24	Sprayed	16		2	26	44
February 24	Unsprayed	4			7	11
March 2	Sprayed	1	1		8	10
March 2	Unsprayed	1			3	4
March 9	Sprayed	13	1	1	25	40
March 9	Unsprayed			1	5	6
March 16	Sprayed	6		4	18	28
March 16	Unsprayed				6	6
March 23	Sprayed	3		7	25	35
March 23	Unsprayed	4	1		5	10
March 23	Unsprayed	2	1		5	8
March 31	Sprayed	3	2		17	22
March 31	Unsprayed	5	4		3	12
April 6	Sprayed	7			21	28
April 6	Unsprayed	2	4		13	19
May 5	Sprayed		1		7	8
May 10			2		4	6
Total		301	31	23		Average 21

The absolute disappearance of *Etiella* during January and February is well shown in the above record of counts, and its scarcity during March. During the entire period, not a tenth as many *Etiella* caterpillars were noted as of *Fundella*, and *Maruca* was even less abundant. The average infestation appears considerably higher during the winter than in the spring, but it must be remembered that only culls were examined during the winter, while representative samples were available for examination from the previously observed late spring crop.

A part of one unsprayed field observed during the winter had sword beans interplanted between every five rows of lima beans, and a row of *Crotalaria incana* along one side. The *Crotalaria* did not begin to have pods until early in March, consequently no observations could be made on whether the insect passed the winter months on this (supposedly) preferred host, rather than on lima beans. No caterpillars were noted in these pods until the latter part of March, when lima beans were also beginning to be infested. On March 24th, several hundred *Crotalaria incana* pods were available for examination, of which only 2 or 3 per cent were infested by *Etiella*. On April 5th, 200 pods were examined and 15 per cent were found to be infested. In only a few cases were caterpillars present, but the indications of their former presence were unmistakable, a webbing together of the seeds, quite different from the clean injury caused by the larvae of *Utethesia ornatrix*. The *Etiella* caterpillars in *Crotalaria* have quite a different appearance from those which have fed on lima beans, having a shrunken, shriveled look, are more bluish-green in color and invariably have four longitudinal purplish-chestnut stripes running along the back. On May 12th, 444 pods were available for examination, and of these 18.5 per cent were, or had been, infested by *Etiella* caterpillars.

The sword beans also, altho planted at the same time, did not begin to come into production until several weeks after the lima beans were bearing heavily, and were as heavily infested by *Fundella* caterpillars as were the lima beans. Indeed, at no time were many sword beans attacked by either *Fundella* or *Maruca*, and, reviewing the observations now, it becomes apparent that sword beans can be of little value in attracting the moths away from the lima beans unless planted several weeks or a month in advance. Heavy infestations of these caterpillars in sword beans have been observed to occur only when the sword beans came into production at about the time the adjacent lima beans ceased to have many pods.

Out of all the hundreds of caterpillars collected, only one *Fundella*

was observed to be parasitized. It bore four globular, semi-transparent, greenish maggots attached to one side, which increased rapidly in size, becoming fully grown on the day after the drawing (See Fig. 6) was made, spinning cocoons of grey silk by the next day, and appearing as ant-like adults ten days later. These wasps were identified by Mr. A. B. Gahan as *Perisieriola* sp., probably *cellularis* (Say).

As explained in a previous paragraph, the lima beans examined during the winter of 1931–32 were only culls. From such inspections it was impossible to determine whether spraying with Bordeaux and magnesium arsenate had any effect on the pod-boring caterpillars, or not. From a casual inspection of the returns, it would seem the caterpillars were more abundant in the sprayed beans, and it appeared possible this might not be merely the appearance, but the reality. Spraying might cause the small caterpillars to burrow into the pods earlier than they otherwise do normally, thus actually de-

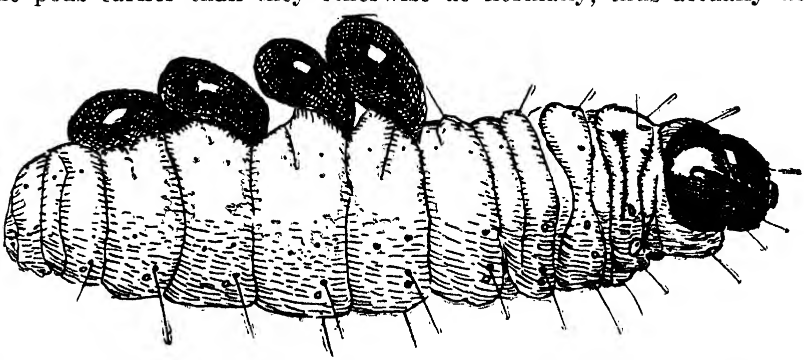

FIG. 6. Caterpillar of *Fundella cistipennis* Dyar parasitized by maggots of *Perisierola* prob. *cellularis* (Say). About fifteen times natural size. (Original).

creasing the number of deaths due to predators and other accidents befalling them while feeding outside of the bean tissue. To more definitely determine the value, or otherwise, of spraying, a specific experiment was conducted during the late spring of 1932. The plan of this experiment was as follows:

1. *Crotalaria incana* (1 row)
2. *Canavalia ensiformis* (2 rows)
3. Lima beans—untreated (3 rows)
4. Sprayed weekly with Bordeaux mixture, 2–2–50 and Magnesium Arsenate (3 rows)
5. Sprayed weekly with Bordeaux only (3 rows)
6. Check (3 rows)
7. Sprayed with poison only, 2 pounds in 50 gallons water (3 rows)

8. Check (3 rows)
9. Sprayed with Bordeaux & poison (3 rows)
10. Check (3 rows)
11. Poison only (3 rows)
12. Check (3 rows)
13. Bordeaux only (3 rows)
14. Bordeaux & poison (3 rows)
15. Untreated (3 rows)
16. *Canavalia ensiformis* (2 rows)
17. *Crotalaria incana* (1 row)
18. *Canavalia ensiformis* (3 short rows)

The seed was planted March 3, 1932, and two weeks later both kinds of beans were up, the lima beans having second and third leaves on. The *Crotalaria* shoots had not yet appeared at this time, and indeed germinated so poorly that, for the purposes of the experiment, their presence may be disregarded. It should be noted that the experiment repeats itself in the reverse order, so that Untreated 3 and 15 are comparable, being beside alternate hosts, while the other untreated rows are true checks, being between sprayed rows. The beans from all comparable treatments were combined for selecting samples for examination, and, so far as possible, these consisted of 100 marketable pods. The first samples were received on June 7th, the last on July 19th. Neither *Maruca* nor *Fundella* caterpillars were found in any beans, all caterpillars being *Etiella zinckenella*. It should be especially noted that these infestations were not in cull beans, nor in run of the field but, in selected, and apparently marketable beans. The extremely high infestation by *Etiella,* does not, however, indicate that this insect is a serious pest of lima beans grown for export to the United States, for these beans were grown during the summer, when no green beans in the pod can be shipped.

SPRAYING EXPERIMENT FOR THE CONTROL OF LIMA BEAN POD-BORER, (*ETIELLA ZINCKENELLA* TREIT.), SUMMER OF 1932, AT ISABELA, PUERTO RICO)

Average	Treatments	June 7	June 15	June 22	June 29	July 8	July 19
31.....	Untreated, beside sword beans	40	20	24	41	38	23
40.5...	Untreated check..........	49	29	35	40	50	1[illegible]
31.6...	Sprayed with Poison only.	37	27	32	29	39	28
36.....	Sprayed with Bordeaux only	44	34	27	36	47	29
48.....	Sprayed with Poison and Bordeaux	53	46	47	26	66	4[illegible]
	Average Examination..	45	31	37	34	48	34

Several of the *Etiella* caterpillars collected in these examinations were parasitized by maggots similar in general appearance to the ones previously observed on the *Fundella* caterpillar, but in color a dull pinkish. They developed with similar rapidity, but spun tough

brownish cocoons, the adults emerging ten days later being quite different in appearance. These wasps were identified by Mr. C. F. W. Muesebeck as *Heterospilus etiellae* Rohwer.

The results of this experiment are not especially convincing, for the presence of *Canavalia* beside the unsprayed rows could have no possible effect on the infestation of the lima beans by *Etiella*, as sword bean is not normally a host of this caterpillar. (It should be mentioned that these sword beans were infested by *Fundella* caterpillars, even tho none occurred in the lima beans). It would, however, tend to indicate that the less one sprayed, the better, and certainly could be interpreted to mean that any expense for spraying could not be justified on the basis of its value in the control of pod-borer. The most serious criticism of the experiment, however, is that it deals entirely with the one pod-borer which does not ordinarily affect the beans grown in the winter for export. For practical purposes, the grower is concerned with *Fundella*, and with *Maruca* only as an unusual abundance may affect the possibility of meeting quarantine requirements, but with *Etiella* not at all, because it is not subject to quarantine, and also because it is so scarce in lima beans grown in the winter. Yet this experiment, conducted during the summer, concerned only *Etiella*.

To meet all of these criticisms, if possible, another experiment was planned, to be conducted during the winter, producing lima beans at the time and under the conditions affecting commercial growers. As one grower, whose statement was quoted and given considerable publicity by one of the companies marketing extracts of pyrethrum, claimed to produce lima beans that had no difficulty in being passed by the quarantine inspectors on account of infestation by pod-borers (whatever that claim might mean), pyrethrum was added to the substances tried. The only possible value for any insecticide in the control of any of these pod-borers would be in killing the eggs or the small caterpillar before it had entered the pod. To kill such minute caterpillars, a contact insecticide might be as valuable as a stomach poison, thus a trial of nicotine sulfate was added to the experiment. The Nicotrol (nicotine sulfate plus penetrol) used was contributed by the Kay Fries Chemicals Inc., and the pyrethrum, in the form of "Pyagrol", by John Powell & Co., to which firms the writer is thus indebted. The plan of the experiment is as follows:

1. *Canavalia ensiformis* (3 rows).
2. Untreated (3 rows).
3. Weekly spraying with Bordeaux mixture, 2–2–50 and Magnesium Arsenate, 2 pounds to 50 gallons of mixture (3 rows)

4. Bordeaux only (3 rows)
5. Check (3 rows)
6. Bordeaux plus "Nicotrol" (Nicotine Sulfate and "Penetrol") 1 part to 200 of liquid (3 rows)
7. "Pyagrol" (Pyrethrum plus "Penetrol"), 1 part to 200 of water (3 rows)
8. "Pyagrol" (3 rows).
9. Bordeaux plus "Nicotrol" (3 rows).
10. Check (3 rows)
11. Bordeaux only (3 rows)
12. Bordeaux & Magnesium Arsenate (3 rows)
13. Untreated (3 rows)
14. *Canavalia ensiformis* (3 rows)

Seed was planted on November 18, 1932, and weekly spraying commenced as soon as the first bloom appeared, about two months later. The first samples, 100 pods, unselected, from each series of rows, were received on February 20th, 1933, and as the experiment was being conducted in reversed duplication, were combined to form samples of 200 pods from each treatment. The sixth lot of samples, received March 27, consisted of the total production for that week, but was insufficient to make up the total number of the other samples. Production practically ceased for a time thereafter, but the seventh shipment, April 20th, was of the required number. The experiment was conducted in Isabela, but examinations were made at Río Piedras on the day after picking.

SPRAYING EXPERIMENT IN THE ATTEMPTED CONTROL OF THE LIMA BEAN POD-BORER CATERPILLARS: *FUNDELLA CISTIPENNIS* DYAR. *ETIELLA ZINCKENELLA* TREIT. *MARUCA TESTULALIS* GEYER, CONDUCTED AT ISABELA, PUERTO RICO, WINTER AND SPRING OF 1933

	Number of Caterpillars per 100 Pods (Samples of 200)									
Dates	Feb. 20	Feb. 27	March 6	March 13	March 20	March 27	April 21	April 29	May 10	May 20
Treatments:										
Beside *Canavalia*	2.5	6.0	4.0	2.5	6.0	7.1	3.5	1.5	9.5	17.5
Bordeaux & Mg. Arsenate	5.0	4.0	2.5	4.5	4.0	5.0	1.0	6.0	5.5	10.0
Bordeaux only	3.0	5.0	2.0	4.0	4.0	6.3	1.5	3.5	5.0	11.0
Check	3.5	10.0	5.0	4.0	5.0	3.7	4.0	4.5	4.5	14.0
Bordeaux & Nicotrol	2.5	4.0	6.0	5.0	3.5	1.4	.5	2.5	3.5	8.0
Pyrethrum	1.5	1.5	5.5	3.5	4.5	3.2	1.5	3.5	5.5	6.5
Average	3.0	5.1	4.1	4.	4.5	4.5	2.0	3.6	5.6	11.3
Total Caterpillars Identified each examination:										
Fundella	19	23	20	7	13	5	3	0	2	6
Etiella	0	0	1	3	2	2	1	8	16	60
Maruca	1	4	0	1	0	0	1	1	0	0

The first two examinations appeared to indicate that the caterpillars were being controlled in the rows sprayed with pyrethrum.

Most unfortunately, later pickings failed to show any advantage from the use of this extract, and indeed sprays with other substances gave even lower infestations during some later weeks. Of course it is possible that the use of pyrethrum at greater strengths, or oftener, might give complete control, but it is doubtful if such treatments would be commercially practical. Thus the experimental evidence, to date, indicates no method of control for the lima bean pod-borer caterpillars.

The final experiment, valueless from the control standpoint, is most interesting otherwise in indicating just when *Fundella* caterpillars cease to be abundant in the spring and their place is taken by much greater numbers of *Etiella,* fully a month after shipment to the States has been discontinued on account of quarantine restrictions.

THE LARVAL PERIOD OF DIAPREPES ABBREVIATUS L.

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In proportion to its economic status, the weevil root borer of the West Indies, *Diaprepes abbreviatus* L., (=*spengleri* L.) has received surprisingly little careful study. Most of our information regarding the insect has been confined to the period of its aerial existence; what happens to the subterranean forms is for the most part inferred rather than known. The exclusively aerial adults, large weevils striped with black and white or bright colors, feed on the tender leaves of many kinds of trees and plants. Clusters of from ten or a dozen to several hundred oval eggs are laid between two older and tougher leaves glued together, hatching of the grubs occurring in six to ten days. The grubs do not burrow thru the leaf, all such holes being made by the wasp parasites, but wiggle out from between the leaves, dropping at once to the ground, into which they burrow. From the beginning, they feed only on live vegetable tissue, so far as known attacking all kinds of plant roots with impartiality. After a larval period presumed to occupy most of a year, pupation occurs in a cell at some depth in the earth. The pupal period is short, about fifteen days according to all observers. Some time may be spent as adult in the pupal cell, but once the adults have emerged from the earth, they never again return to it.

Injury to economic plants is caused by both larva and adult, citrus trees and sugar-cane being most often attacked. In Barbados, the insect is practically restricted in all host relationships to sugar cane: the adults feeding on the leaves, the females laying eggs between the split tips of the leaves, the young grubs feeding on the roots, the older grubs burrowing into the root-stalk, and the pupa often being formed in a cavity in the cane stool. Elsewhere the adults feed on the leaves of many wild and a few economically valuable plants, and the grubs are apparently unrestricted in their choice of roots on which to feed.

The range of the insect is from Barbados to eastern Hispaniola, and over this range the adults differ so greatly in color markings and general appearance that numerous varieties and species have been described, all of which, we are assured by the systematists, belong to but a single species. The variation in the size, color and habits

of the adults may appear in the grubs as a variation in behavior and length of the larval periods, for regarding the latter, no observers agree. Over thirty years ago, that enthusiastic amateur entomologist, the Rev. N. B. Watson, in Barbados reared a few individuals from egg to adult and determined the larval period as being from 300 to 312 days. A dozen years later, Wm. Nowell in Barbados found 261 days, 326 days and 334 days as the length of time before pupation for rearing immatures grubs of small size. Judging by the few completed rearing records, the larval period in Puerto Rico may be considerably shorter. Three grubs only, out of the hundreds used in the experiments that have been conducted here in the past two years, have been successfully reared from the just hatched larva to pupa, the larval periods for these three grubs being 202 days, 238 days and 268 days respectively. (See Table, p. 259.)

All of the grubs have been carefully observed as to molting; the one attaining the pupal period in 202 days pupating from the 10th larval instar, the one pupating in 238 days having attained complete larval development in only six instars, while the one requiring 268 days to become a pupa changed from the ninth instar. From such a small number of individuals, no generalization of value can be made, and indeed one can not be sure that these individuals pupating in such a short period are not exceptional rather than normal individuals. Other grubs have molted to the 16th instar, in one case after only 220 days, while other individuals have lived over a year as larvae. Not one of these other grubs, however, has succeeded in evading the varied perils inherent in the more or less unnatural conditions attendant on artificial rearing and constant observation, and most of them have died before pupation. Unquestionably, all of these grubs were sound and healthy in their earlier instars, while they were growing rapidly and making constant gains in size and weight, but having attained maximum weight, they entered a period of inactivity and failure to eat, a cul-de-sac from which the only escape was not pupation, but death. A few of these grubs are still alive, but the stimulus which will cause them to continue their transformation is not yet determined. Admittedly the present paper is incomplete and essentially preliminary. While the completed rearing records may be considered as finished and final, all the general statements made are tentative, and subject to change as additional results accumulate.

The first year's rearing was conducted at Isabela, the second at Río Piedras, and despite the fact that the same type of container, the same cabinet for holding the rearing boxes, the same food and in

LARVAL PERIODS OF *DIAPREPES ABBREVIATUS* L., SELECTED INDIVIDUAL RECORDS AND AVERAGES OF ALL RECORDS: DAYS AFTER HATCHING TO BEGINNING OF INSTAR

	Completed normally			Incomplete: died before pupation												Averages of All Records	
Reared at	Río Piedras	Isabela		Río Piedras						Isabela						Río Piedras	Isabela
Instars / Date hatched	Sept. 10	July 5	May 5	Dec. 24	Oct. 5	Sept. 1	Aug. 5	Oct. 5	Aug. 5	Jan. 19	Nov. 17	Oct. 1	May 5	June 22			
2nd	12	31	27			12	10	10	17	31	23	8	11				28 34 grubs)
3d	21	38	33	23	19	21	20	20	29	59	41	18	32	32	89	21 (77 grubs)	46 (34 grubs)
4th	25	51	42	34	24	30	29	29	44	78	77	38	64	52	135	29 (82 grubs)	66 (38 grubs)
5th	33	145	57	39	33	35	41	41	57	103	94	106	92	101	163	37 (84 grubs)	100 (37 grubs)
6th	42	172	130	46	42	53	51	52	66	114	103	156	200	134	251	47 (82 grubs)	146 (34 grubs)
7th	82		153	53	49	62	63	73	110	124	132	185	219	163	305	62 (82 grubs)	184 (30 grubs)
8th	115		211	59	71	72	83	92	136	138	143	210	273	256	339	88 (88 grubs)	221 (21 grubs)
9th	128		227	81	101	86	103	114	166	167	183	280	316	305		117 (80 grubs)	262 (13 grubs)
10th	173			107	124	102	125	134	196	192	233	308	339	340		148 (68 grubs)	300 (6 grubs)
11th				130	141	123	148	145	228			355		361		170 (52 grubs)	
12th				161	159	142	166	152	246							195 (38 grubs)	
13th					202	156		156	263							218 (18 grubs)	
14th					217	177		171	285								
15th					227	191											
16th					239	220											
				Minimum to 8th instar	(Fed corn only)			(Fed beans only)	Maximum to 8th instar for Río Piedras	Minimum to 8th instar for Isabela					Maximum to 8th instar		
Pupa	202	238	268														
Adult			289														

many cases the same soil were used in both localities, the grubs attained full size in a much shorter time at Río Piedras. The factors of difference, so far as known, are three. The grubs were examined every week at Isabela, but at Río Piedras they could be watched more carefully, examinations being made usually three times a week. The water used to moisten the soil at Isabela was taken from the irrigation ditch; that at Río Piedras was city water which often was heavily chlorinated. The mean minimum air temperatures at Río Piedras averaged two or three degrees lower than at Isabela during the winter only, otherwise they were practically the same. How this affected the soil temperatures is problematical. The speeding up to growth in Río Piedras applies also to the total larval period, for the minimum of 202 days was obtained here, the other two records being of Isabela grubs. It was not a characteristic of the grubs themselves, for some of the grubs reared at Río Piedras were from egg-clusters collected at Isabela, others were from Florida (between Arecibo and Barceloneta), only the minority being obtained locally.

Various sizes of tin salve boxes have been used as containers, but finally the two ounce size was adopted for all work as being the most desirable. The soil used was that most readily available outside the laboratory door, the only selection being to eliminate large sticks, stones or other debris, the earth particles carried up out of their tunnels by ants often being selected. At first, soil brought from Isabela was used at Río Piedras, until a considerable expansion of the experiment required additional amounts, which were picked up locally. In many cases, previously discarded soil which had been thoroly dried or baked was used in preference to obtaining fresh soil from the garden. Moisture was added by means of a medicine dropper, attempting to keep the soil reasonably moist at all times, and only excessively moist when seeds were to be sprouted.

As food for the grubs, corn only was used at first; later, fresh lima beans were added. As the lima beans were subject to rot, sword beans were substituted, the usual combination placed in one box with a grub being two grains of corn and one bean. So far as could be determined, the grubs fed on the corn or beans with strict impartiality, and apparently throve equally well on either. To determine the effect of food on rapidity of growth, half the grubs from one egg-cluster hatching on October 5th were placed in cans supplied only with corn, the others in cans supplied only with sword beans.

In the first instar, the mortality was greater among the grubs supplied only with corn, so that only five survived, as compared with twice as many which lived to eat beans. Yet these five grubs eating corn averaged from two to fourteen days less time in reaching each instar up to the ninth. By the tenth instar, however, when all the grubs had ceased feeding, those which had previously eaten only sword beans molted nine days ahead of those previously eating corn. In the molt to the 11th instar, the corn-eating grubs were one day ahead, in the molt to the 12th, nine days ahead, yet in the molt of the 13th, their respective positions were again reversed, those which had eaten corn being three days ahead (214 days vs. 217 days). Such slight differences may be considered as due to individual variation, and indicate that no significance is to be assigned to food.

Extreme seasonal variation in abundance of adults has repeatedly been noted, yet adults are present at all times, and egg-clusters have been collected during every month of the year at both Isabela and Río Piedras. No special effort has been made to rear grubs from the eggs of every month, and indeed only minor differences are to be noted in rapidity of growth of the grubs during the warmest and the coldest months. It is possible that the grubs grow most rapidly during cooler (tropical) weather, and the majority of the rearings would appear to indicate this, yet so many individual exceptions are to be noted that it is by no means certain. Some grubs hatching from egg-clusters laid in December have attained maximum size in two months, or a little longer, but other individuals from the same cluster required as long, or longer, than grubs hatching out early in August. Individual variation is much greater than seasonal variation, some of the grubs from one large egg-cluster hatching in December requiring more than twice as long to make the same gains in size and weight as others from the same cluster. Some grubs are exceptionally slow in the earlier instars, others in the later growth instars, all from the same egg-cluster, and reared under as nearly as possible the same conditions. Inividual variation in rapidity of growth does not follow the normal curve, for the majority of grubs are close together, making rapid gains in size and weight with none greatly in advance, but the minority strings out almost interminably behind Some of the delayed minority may later catch up, or almost catch up with those which have made the most rapid growth at first, and others are permanently greatly delayed, yet they seem as healthy and normal as any others. (See Plate XX.)

No explanation can be given of the failure of some grubs to eat and grow as fast as others from the same cluster, more especially

when all were in the same container during the earlier instars. An abundance of food was available at all times, and the grubs were so active that they could hardly have failed to come into contact with it. Molting, however, at least during the earlier instars, is to some extent dependent on soil moisture, being inhibited when the soil is dry, but ensuing within a few minutes after a sudden access of water. Wm. Nowell is of the opinion (**2**) that pupation also normally follows spring rains after the comparatively dry winter weather of Barbados, but no pertinent observations on this point have been made in Puerto Rico.

The larval period of *Diaprepes* grubs falls into two parts: (1) a period of constant and rapid growth, extending from hatching to about the beginning of the eighth instar, during which time the head-size of each instar is noticeably different so that each instar may at once be recognized by examining the grub itself, and (2) a period of equal or even greater length when the size and weight of the grub remains constant, or tends to decrease, extending from the eighth instar, or earlier, to pupation, during which period the number of molts can be determined only by keeping track of the molted skins. In the first period, the grub is feeding most of the time, in the second it eats little or not at all. Some individual grubs in the second period molt almost as frequently as previously, but most of the grubs at much greater and very irregular intervals. Individual variation is even more marked than in the first period, and the problem of maintaining the grubs alive and healthy becomes increasingly difficult. So few of the grubs have successfully passed thru this period of inactivity under artificial rearing conditions that most of the data accumulated concerning it is admittedly false. It seems very improbable that under normal conditions it usually ends in the death of the grub. All the activities of the insect occupy less than half a year, but this long, indefinite and indeterminate waiting period of the larva before pupation stretches out the life-cycle so that it will fit into the seasonal pattern of a year. It suggests that the insect should be better adapted to a climate inducing a long period of hibernation or aestivation, altho the period does not, or may not, actually coincide with any extended period of temperature difference.

Regarding the first period of activity and rapid growth we can be much more certain that the data accumulated are reasonably correct. Grubs in both periods have been weighed during all instars, not the same individuals, but ten or a dozen individuals in each instar, and, with some minor adjustment of these averages, we can be reasonably certain that the majority of the grubs in this first period make

steady and constant gains in weight. To be sure, this steady gain is interrupted at every molt, for every molt results in a small temporary loss, but if one considers the gain from about the middle of one instar to the middle of the four succeeding instars, the resulting curve will be a straight line. Starting with the newly hatched larva weighing .000125 gr. each, in each of the succeeding five intervals of ten days, at Río Piedras, (from hatching to the middle of the first instar, from the middle of the first instar to the middle of the second, from the middle of the second to the middle of the third, etc., each one of which is approximately a ten day interval at Río Piedras) the increase in live weight is *four* times: to .0005 gr., to to .002 gr., to .008 gr., to .032 gr., to .128 gr. by the middle of the fifth instar. This is the period of most rapid growth.

Following it is a transition period of less rapid growth. From the middle of the fifth to the middle of the sixth instar,, the interval is no longer, but the increase in weight is only *three* times, to .384 gr. From the middle of the sixth to the middle of the seventh instar, the interval is one-half longer, to fifteen days, and the increase in weight is only one and one-quarter times, to .48 gr. Individual grubs may weigh considerably more than this in the 7th and later instars, the maximum observed for any grub being .74 gr. for one individual in the 9th instar. The average weight, however, of those in any of the later instars is .5 gr. or a little less. Most grubs attain their maximum weight in the eighth instar. For most grubs, and for the average of all grubs, molting to the eighth instar marks the end of the period of growth and the beginning of the period of inactivity preceding pupation. At Isabela, the period interval between the middle of succeeding earlier molts, instead of being ten days as at Río Piedras, was fifteen days, and in addition to being one-half longer, began to lengthen earlier, to thirty days between the middle of the fourth instar to the middle of the fifth, and to forty days for the succeeding instars.

Up to the middle of the fifth instar, the grubs are of insignificant size so far as the damage they are capable of causing to the roots of plants is concerned, but the slowing down of their rate of growth coincides with the period when they are of sufficient size so that the result of their feeding activities is a very noticeable loss to the farmer. That they should grow so rapidly in the first two months results in no noticeable and obvious injury to well established plants, but their feeding in the next month results in the maximum injury they are capable of causing. This point is of the greatest practical im-

portance to farmers, especially those who are growing vegetables between young citrus trees for instance. The appearance of large numbers of adult beetles feeding on the tender leaves of their citrus trees is not only a direct loss of foliage but indicates that in from two to three months later the roots of these citrus trees and the roots of vegetables growing between them will suffer the maximum injury from the grubs hatching from the eggs laid by the female beetles. After this period of greatest injury to the roots, fully grown grubs may be present in the soil and around the roots for several months, but the injury they cause is all past. They are no longer actively feeding. Their growth curve has dropped to zero.

Two kinds of curves may be drawn to represent what has happened. The one representing relative growth is at a high level for the first two months, drops slowly at first but later with increasing rapidity in the third month, and by the fourth month is below zero, continuing here until pupation. The curve showing absolute weights is scarcely apparent in the first month, rises rapidly in the second month, makes enormous gains in the third month, a slight gain in the fourth month (but still at a high level), and drops only a little below this high in the succeeding months to pupation. Except in the latter months, it parallels the curve of injury to the farmer's crops, insignificant in the first two months, attaining a maximum in the third and fourth months, but again dropping to insignificant proportions later, when the grub has ceased to feed and is merely waiting for pupation.

BIBLIOGRAPHY

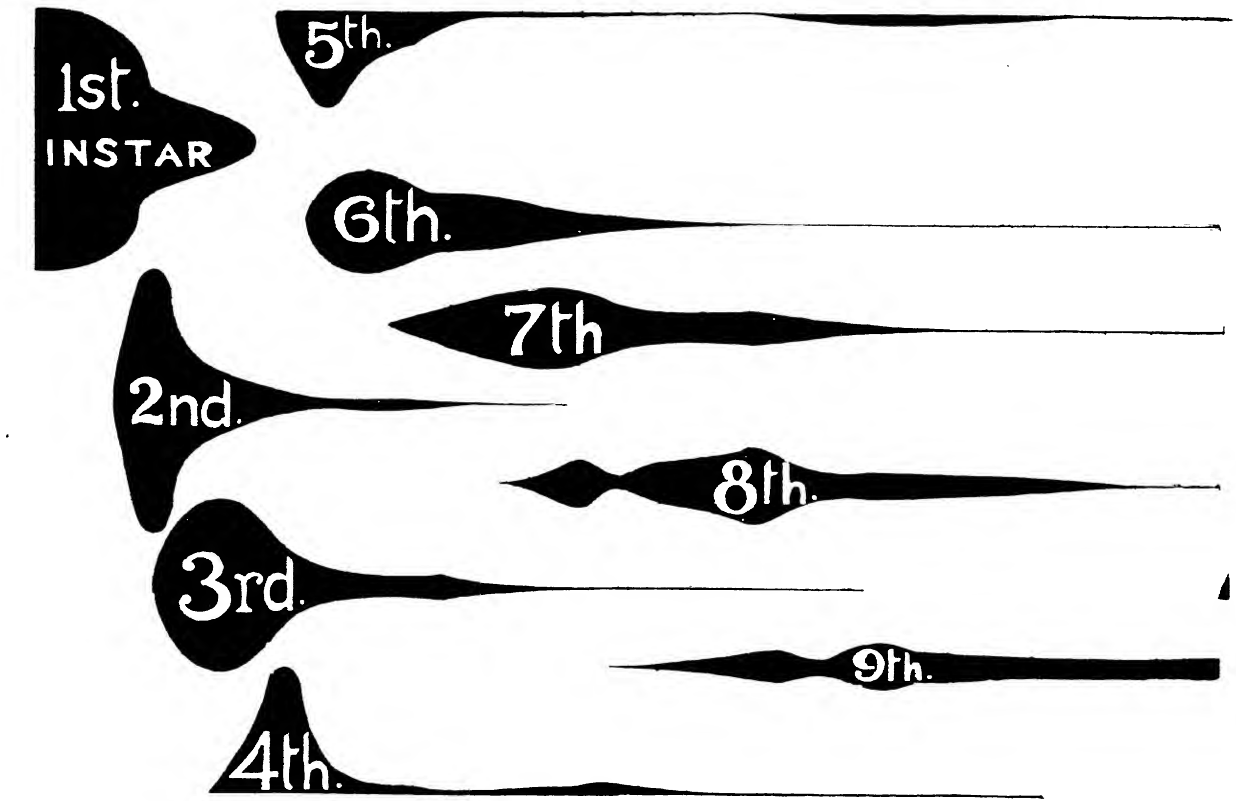
1. **Watson, N. B.,** "The Root-Borer of Sugar-Cane (*Diaprepes abbreviatus*)." West Indian Bulletin, **4**: (1) pp. 37–47, fig. 3. Bridgetown, Barbados, 1903.

2. **Nowell, Wm.,** "Report of the Assistant Superintendent of Agriculture on the Entomological and Mycological Work carried out during the Season under review." Rpt. Dept. Agr. Barbados **1912–13,** pp. 34–45. Bridgetown, 1913.

PLATE XIX.

Injury of caterpillars of *Fundella cistipennis* Dyar to pods of sword beans. Note only one uninjured pod of all those shown, the smaller pods being withered and about to drop, the larger ones being malformed by infestation at a later stage of growth. (Original).

PLATE XX.



Length of Larval Instars of *Diaprepes abbreviatus* L. at Río Piedras: total horizontal distance represents two hundred days, vertical distance indicates number of grubs. (Original. Drawn by Fernando Chardón.)

THE CHANGED STATUS OF SOME INSECT PESTS IN PUERTO RICO

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A few of the insect pests of economic crops in Puerto Rico show little or no change in their status over a period extending as far back as any entomological observations are recorded. For instance, the purple scale of citrus trees, *Lepidosaphes beckii* Newman, has been and still is THE scale for which growers spray or maintain windbreaks, obtaining commercial control thereby, but never reducing its numbers below a certain minimum from which it will promptly recover under favorable conditions. The mole-cricket, or *changa, Scapteriscus vicinus* Scudder, is generally quite as much of a pest now as it has ever been in the past, the decrease in its numbers reported by some farmers due to toads being more than balanced by increased damage reported in other districts, due either to a more intensive type of agriculture or to an actual increase in its numbers. In the regions where the use of the standard Paris green-flour mixture for poisoning the *changa* is still in common use, it probably is now less abundant than formerly, but where farmers have reverted to merely protecting young plants against its attack by wrapping them in *mamey* leaves when transplanted, it is subject to no control except natural factors. To be sure, it is eaten by the imported giant toad, *Bufo marinus*, but apparently only in limited areas has a noticeable reduction in its numbers resulted.

Of the pests which have appeared here in recent years, the latest arrival is the cottony cushion scale, *Icerya purchasi* Maskell. A detailed account of this insect is given elsewhere in this number of the Journal (**1**), noting its peak of abundance in the late spring of 1932, and the role of parasites, predators, entomogenous fungi and hurricanes in its control. *Coccus viridis* Green, the soft green scale of citrus and coffee, was first noted in 1925, and became noticeably destructive in the coffee groves denuded of shade by the hurricane of San Felipe in 1928. Its present status largely depends on local humidity, for its numbers are greatly reduced by at least two kinds of entomogenous fungi attacking it, which thrive during wet weather. Thus it is rarely injurious on large citrus trees, or in coffee groves well protected by shade, but during dry weather may be seriously

injurious on young citrus trees. In 1921, two pests appeared almost simultaneously in Puerto Rico, the pink bollworm of cotton, *Pectinophora gossypiella* Saunders, and the corm borer of plantains and bananas, *Cosmopolites sordidus* Germar, both of which now occur practically everywhere that appropriate host plants are present. The latter pest apparently has no natural enemies, and comparatively few growers practise, or even know, the practical methods of control by which its numbers may be reduced to a minimum. The rapidity with which it has spread, and the abundance in which it is now present, does not indicate, however, that other insects with similar habits will be similarly successful. The sweet potato weevil, *Cylas formicarius* F., altho a most serious pest in the poor, hilly lands of the interior, is of comparatively little importance on the richer loams or the sandy lands of the coast, where the host grows to much better advantage, matures more rapidly, and is further protected from attack by the absence of cracks in the soil thru which the insect can reach the tubers. Even less successful in extending its range is another weevil of sweet potatoes, the scarabee, *Euscepes batatae* Waterhouse, which is still confined to limited areas where the first records of its presence in Puerto Rico were made. Its limited distribution is paralleled in the case of the papaya fruit fly, *Toxotrypana curvicauda* Gerstaecker, which is comparatively rare even in the restricted region where it is present.

For the 29-year period, 1899 to 1928, no generally and seriously destructive hurricanes have happened to strike Puerto Rico. One consequence of this lengthy immunity from hurricanes was that the coffee shade tree ant, the "hormiguilla", *Myrmelachista ambigua ramulorum* Wheeler, became constantly more abundant, for old infested shade trees in the coffee groves became so large that they could not be removed without injury to the coffee trees underneath. The hurricane of San Felipe brought down these old guaba and guamá trees, thus immediately eliminating the great bulk of the hormiguilla population of the grove. Only gradually, over a period of several years, as the freshly planted shade trees again attain considerable size, will the numbers of the hormiguilla again begin to increase.

The hurricane incidentally increased the number of the more common cotton insect pests in the few years immediately following, for the impoverished coffee growers in many cases attempted to grow cotton for a cash crop. Waves of infestation by the leaf caterpillar, *Alabama argillacea* Hübner, swept over these plantings, and infestations of the pink bollworm were built up, culminating in almost

total infestation of the end of the crop for 1931–32. From this high peak, cotton insects rapidly receded, due to the discouraged coffee planters abandoning the crop, and even cotton farmers ceasing to plant on account of low prices and the withdrawal of the sole buyer. The hurricane of San Ciprián in the fall of 1932 destroyed the fruiting portions of the maga trees, thus eliminating the only important alternate host of the pink bollworm along the north coast. Where volunteer cotton plants still exist, the pink bollworm continues to persist, but in the main cotton region, around Isabela, where volunteer cotton plants had been eliminated years ago, the destruction of the fruiting portions of the maga trees and the absence of commercial cotton fields have, temporarily at least, entirely eliminated this pest from the region.

Replacing the old standard varieties of sugar-cane grown in Puerto Rico with BH (10)12 and SC 12(4) has considerably increased tonnage and sugar content, but it has also affected the common caterpillar, *Diatraea saccharalis* F., which bores in the stalks, most advantageously to the insect. The new canes are larger and softer and sweeter than the old, and they appear to furnish a more desirable environment for the insect. Thus the numbers of this, the most serious pest of sugar-cane, have been on the increase, despite the fact that the non-burning of trash has been ever more widely adopted. Favoring its parasites by non-burning of trash can not begin to neutralize the effect of a more favorable environment furnished by the new varieties of cane. Thus, altho the net result of the change of varieties has been to increase production, this is despite the greater losses at present being caused by *Diatraea*. The stalk borer is not the only insect affected by the change in varieties. What was previously only a minor pest of sugar cane, the yellow aphid, *Sipha flava* Forbes, has also thereby been provided with a greatly superior host, from its standpoint. Because of some undetermined peculiarity of Uba and the Java canes, it often becomes enormously abundant on these varieties, and such mass infestations spread to adjoining fields of B H (10) 12 and S C 12 (4), causing much greater and more extensive losses from this pest than were ever known on the standard varieties.

The major and most obvious change which has occurred recently is in the status of white grubs, the numbers of which have decreased so greatly that only rarely and sporadically do they cause serious damage. Fifteen or twenty years ago the damage caused by white grubs had attained its maximum, and at that time they were the

most serious pests of practically every crop grown on the island, such damage being most severe in the irrigated cane lands of the south coast. It was a common occurrence to have nearly mature cane so completely denuded of roots that the stalks could be pulled up with ease, or, in extreme cases, they would fall to the ground at a touch. White grubs were distinctly the main entomological problem in Puerto Rico, and a consideration of methods of control occupied the attention not only of entomologists but of cane growers and field men generally. As none of the methods of chemical control or parasite introduction proposed by the entomologists proved to be economically feasible, or likely to produce results within a reasonable time, the field men were forced to adopt such obvious methods as hand picking of the grubs after the plow and of the adult beetles from young cane, expensive, essentially temporary and only partially effective as such methods admittedly were.

Today it is difficult to realize the seriousness of the white grub menace, for the grubs are no longer present. Hand collection of the grubs and beetles has been almost universally abandoned because it is no longer necessary, and is now so exceptionally used in rare instances only as to indicate how greatly the status of the white grub has changed. To be sure, cultivation practises have been improved, plowing is deeper, the land is better fitted for plant cane, and even the kind of cane itself is changed, being more vigorous varieties with stronger and more rapidly developing root systems, but these are only minor factors to account for the practical disappearance of the native white grubs generally from the cultivated fields of Puerto Rico.

The major factor in a changed environment for white grubs is the introduction and wide-spread dispersal of the giant toad, *Bufo marinus* L. Nearly a third of the food of this animal in cane fields consists of May beetles, the adults of the white grubs. If the toads were comparatively scarce, as are the native toads for instance, their influence might be negligible, but as a matter of fact they are at the present time very numerous, not only along the coast, but also far up into the hillier districts of the interior. On account of their individual size, their abundance, and their preference for May beetles as food, they have rapidly changed the status of white grubs in the cane fields of the south coast, and in the agricultural regions of the island generally, from that of a major pest to one of comparatively minor importance. No prediction can be ventured as to how long this condition will last: whether it is merely a temporary low for white grubs, or whether it may possibly be more or less permanent,

a permanent adjustment to the new factor. When the oscillations of the balance of nature are upset by the introduction of a new major factor, usually the numbers of the host are so greatly reduced by the parasite or predator that the parasite or predator shortly must perish in large numbers on account of lack of food. In the case of such an omnivorous predator as the toad, however, not limited in its choice of food to any particular kind of insect, the prospect of many individuals starving to death on account of lack of food may be indefinitely postponed, even if May beetles become much scarcer than they are at present. A considerable number of other Scarabaeid beetles, of little or no direct economic importance, but almost the equivalent individually of the May beetles in size, are very abundant at times, and these constitute even now a seventh of the food of toads in cane fields, and may come to be a more important factor if the number of May beetles shows a decrease below its present previously unprecedented low.

Combining all the Scarabaeid beetle items in the toad's food (amounting to nearly half of all food eaten) and adding to this an additional quarter consisting of millipedes, one can readily see how little is to be expected from the toad in affecting other insects, for the present at least, and so long as a sufficient supply of May beetles and millipedes is available. Eventually the changa may be much more generally eaten, but it was found to be only one-fortieth of the food in 1930–31 (**2**). Is it surprising that the changa continues to be a major pest, and that white grubs have almost disappeared?

At times, and locally, even exceeding white grubs in numbers and in the damage it causes to cane is the weevil root-borer grub, *Diaprepes abbreviatus* L., the adult of which is an exclusively aerial, leaf-feeding, short-beaked weevil. The adult beetles rarely feed on cane leaves, but are a serious pest of citrus trees, especially of young trees which have just been set out in the grove, and they also feed on the tender leaves of numerous other trees of little or no economic value. So far as can be judged, the numbers of this pest now average little less than at any time in the past. Altho the exclusively aerial habits of the adults might appear to render them largely immune from being eaten by toads, the weevils in fact form the third largest single item in its food, an eighth of the total. Eventually this may be considerably increased if other large insects, such as the Scarabaeid beetles, become less numerous, and seems not only possible but decidedly probable. One other important factor tending to limit the number of *Diaprepes* is an egg parasite, *Tetrastichus haitiensis* Gahan. Not until 1929 was this common insect discovered in Puerto

Rico, but its so recent discovery can hardly mean that it was not previously present. The parasite is so common that it ordinarily destroys from 50 to 95 per cent of all egg-clusters laid between the leaves of citrus or wild fig, but it can not penetrate to the eggs when they are laid between the split tips of cane leaves, and these only were collected and examined by the earlier investigators. Thus the egg parasite is not a new controlling factor, like the introduced toad. and is static, not likely to greatly increase in importance in the near future.

If any considerable decrease in the number of *Diaprepes* has already occurred (altho at present imperceptible to entomologists or farmers generally), or does occur within the next few years, it presumably will not be due to egg-parasites, but to a scarcity of other food forcing the imported toad to catch and eat larger numbers of these leaf weevils.

BIBLIOGRAPHY

1. **Wolcott, G. N.** and **Seín, Jr., Francisco.** "A Year's Experience with the Cottony Cushion Scale in Puerto Rico." Jour. Dept. Agr. P. R., **17**: 199–221, pl. 4, ref. 11. San Juan, July (actually September), 1933.

2. **Dexter, Raquel R.** "The Food Habits of the Imported Toad *Bufo Marinus* in the Sugar Cane Sections of Porto Rico." Bulletin No. **74**, Fourth Congress, International Society of Sugar Cane Technologists, p. 6, tab. 11, ref. 6. San Juan, March 1st to 16th, 1932.

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Gum—Producing Organisms in Sugar Cane.
Melville T. Cook and *Pablo Morales Otero.*

Research on Shortening Time Without Affecting the Accuracy of Dyer's Modified Method for Determination in Soils, of Phosphoric Acid, Lime and Potash Soluble in Citric Acid Solution.
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A Variety of Tobacco Resistant to Ordinary Tobacco Mosaic.
J. A. B. Nolla and *Arturo Roque.*

Pineapple Disease of Sugar Cane in Puerto Rico.
White Spot of Pineapple.
Patho—Anatomy of Roots Attacked by Nemathodes.
Melville T. Cook.

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GUM-PRODUCING ORGANISMS IN SUGAR CANE

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The importance of the gummosis disease of sugar cane and the advance in our knowledge of the subject since the publication of the previous papers by the senior author have made a further study of the subject very desirable. The most important of these advancements is in our knowledge of the geographical distribution and of new species or strains.

HISTORY

This disease was reported first from Brazil by Dränert in 1869 but appears to have been known as early as 1863. It was reported next from Australia by Cobb who described the organism in 1894. He believed it to have been in the country as early as 1876. The wide separation of these two countries presented a very interesting problem in geographical distribution. Shepherd, of Mauritius, in his report for the International Survey of the Diseases of Sugar Cane (1932), said that it was probably introduced from Brazil to Mauritius on a shipment of seed cuttings in 1869 and from there to Australia in 1874. North, of Australia, in his report for the same survey, says that it was probably introduced into Australia from Mauritius in 1874. The next report was from Brazil in 1894, but it was less severe than in 1869, probably due to the use of resistant varieties. It was found in Puerto Rico by Matz in 1920 and reported the same year. It was discovered in St. Kitts of the British West Indies in 1925 and reported by Ballou in 1926. It was found and reported from Colombia by Chardón of Puerto Rico in 1926. It was found and reported in Guadeloupe of the French West Indies by Williams

[1] This is the third paper on the gummosis of sugar cane by the senior author. Early in 1932 the junior author began to cooperate in the work and has made the studies on the reaction of sugars to these organisms and also the serological studies.

(**16**) in 1929. It was reported from Dominica of the British West Indies by Ashby (**1**) in 1928–29; from St. Lucia of the British West Indies in 1929, and from Antigua of the British West Indies by Illingworth in 1930.

In addition to the above places it has been reported from Fiji Islands, Java, Borneo, Reunion and New Guinea. The report from Java by Groenewege in 1915 was proven to be a mistake by Wilbrink who published the results of her studies in 1920. The disease which was supposed to be gummosis was found to be what is now known as scald (*Phytomomas albilineans* Ashby). The reports from Borneo and New Guinea have not been confirmed.

The symptoms of the disease have been described by many students of the subject. The descriptions by the various authors are very harmonious. The senior author in his description which was published in 1928 makes the following statement:

> "The most reliable external symptom is the leaf streaks referred to by Matz and Cottrell-Dormer. However, this symptom is sometimes present on POJ canes, and occasionally on Uba and some other canes, although it is impossible to find any trace of gumming in the cut surfaces."

Again in a paper read before the plant-pathology section of the Fourth Congress of the International Society of Sugar-Cane Technologists (1932) (**8**) he said,

> "Although the presence of these stripes is the most important external symptom I am satisfied that it is not always reliable. I have found infected canes which did not show these symptoms and I have found these symptoms in canes which did not show internal gumming or discolorations."

Further studies in Puerto Rico on the symptoms of this disease following the publication of this first paper led to more confusion. The leaf symptoms appeared in several resistant varieties which did not show discolorations or gum in the fibro-vascular bundles of the stems or bacteria in the leaf stripes. Finally the senior author began referring to cases of this kind as "false gummosis". This phase of the problem was solved at the Fourth Congress of the International Society of Sugar-Cane Technologists which met in Puerto Rico, March 1932, when it was found that this "false gummosis" was the same as a disease reported by Dr. Wilbrink of Java in 1929 as "fourth disease" and by Martin of Hawaii in 1930 as "chlorotic streak." It was also learned that this disease had been noted by Bell of Australia who referred to it as "false scald".

The leaf symptoms of this fourth disease or chlorotic streak are very similar to the leaf symptoms of the gummosis. The streaks

may be somewhat broader than in gummosis and the boundaries may be somewhat wavy. As a rule the reddish dots which are characteristic of the gummosis do not develop in fourth disease or chlorotic streak, but there is a reddish margin on the older streaks.

The exudation of gum on the cut surfaces of the canes is the most reliable symptom of the disease. The diseased fibro-vascular bundles are usually discolored, the most common discoloration being red but a discoloration does not necessarily indicate the disease and the absence of gum on the cut surfaces does not necessarily indicate that the cane is free from the disease. During periods of very dry weather diseased canes may show discolorations and but little or no gum. During or following periods of wet weather the canes will show the gum in varying amounts, depending on several factors, such as weather conditions, length of time that the cane has been infected and variety of cane.

Within the past few years certain variations in the morphologic and physiologic characters of the organism have been reported which make further study desirable.

The writer sent cultures to Mr. M. C. Goldworthy of the University of California in 1927 who compared them with cultures sent from Australia by Mr. A. F. Bell for that purpose. Under date of June 27, 1927, he replied as follows:

> "Your vascular types are different from those we have received from Australia. That is they behave differently on media. So far I have had no opportunity of comparing the cultures by the serological method."

Ashby (**2**) (1929) published the results of a study of this disease in the British West Indies in which he reported the finding of two organisms. He said:

> "Plantings in peptone saccharose agar made with yellow ooze from the stalks of affected canes in St. Kitts yielded two types of colonies, these, the more rapidly appearing (3 to 4 days) being entire convex, glistening and, at first, colourless but later pale yellow and spreading: the later appearing colonies were entire, flat, deeper yellow, and the growth more restricted. The first type of colony yielded a straw or amber yellow (Ridgway) abundant slimy growth on slanted agar in tubes with a marked tendency to run down and accumulate at the bottom of the slope; after inoculating into milk a shallow clear zone formed at the top of the liquid in two or three days at tropical room temperature with a bulky indistinct clot apparently due to a labenzyme and the reaction became increasingly alkaline. The second more slowly growing type of colony which was yellow from the start yielded a restricted glistening aniline to primuline yellow growth on the agar with a compact slime showing little tendency to flow. In litmus and plain milk no change occurred in a week but there was gradual increase of alkalinity subsequently. As the organism in the first type of colony

showed cultural characters different from those of *B. vascularum* as described by Erwin F. Smith and as those of the second type were in agreement with his description the first type was discarded and attention given to the second.''

He secured cultures from North of Australia and made inoculations in cane in England which enabled him to compare the St. Kitts organism (second type) with Australian organism. The Australian type produced broader stripes, a withering of the heart and a rotting of the apical internodes. It was more severe than the St. Kitts second type. He said:

''The original cultures of the St. Kitts organism (second type of colony) gave rise to a glistening restricted growth on peptone-saccharose agar (saccharose 2.0, with peptone 0.5, dipotassium phosphate 0.05, magnesium sulphate 0.025, agar (bacto) 1.5, water 100.) between aniline and primuline yellow in colour (Ridgway); the slime was compact drawing out, in cultures which had attained their full growth, into elastic threads and showing little tendency to flow. The growth was opalescent in oblique light and gelatine (10 per cent.) of the same composition as the agar medium was slowly liquefied after two weeks. Lavender-colour litmus milk became gradually strongly alkaline and after two to three weeks at 23° C. began to clear from the surface with bleaching. After two to three months the milk had cleared with more or less suspended slime and restoration of the litmus colour but remained permanently strongly alkaline. If the milk carried a layer of fat a yellow growth developed on the surface and there was little deposit; in the semi-anaerobic conditions under the layer of fat, bleaching of the litmus was complete for a time, and it appeared that action on the milk was mainly by diffusion of metabolic products through the fat layer. In well-separated milk, surface growth was restricted to a yellow ring, there was active multiplication within the liquid and a good yellow deposit associated with partial bleaching and more rapid restoration of the litmus colour. It is doubtful if, at any time, a true clot was formed, the eventual clearing being apparently due to increasing alkalinity since cleared cultures yielded a bulky precipitate when acidified with hydrochloric acid. The organism which was actively motile in young liquid cultures by means of a single polar flagellum exceeded 0.5 microns in diameter and was from 1.0 to 1.5 microns in length occurring singly, in pairs and more rarely in short chains. Most of the isolations showed colonies similar to those of the original isolation but those from the leaf stripes of Uba were dry, flat, rough and pale yellow with wavy margins, the growth from these colonies on agar slants was at first similar but tended gradually to take on the glistening smooth deeper yellow character of the original form. Some of the cultures from the isolations caused, like the original, a slow liquefaction of gelatine but others showed no trace of liquefaction at room temperatures after three months. The action on milk varied in the rate of change but there was no true clot and all eventually cleared with persistent alkalinity.

''The original culture from Australia gave rise on the agar to convex glistening almost colourless colonies of a fluid slimy consistency which became paler yellow and spreading. On agar slants the growth was abundant, opalescent and fluid slimy with a tint from straw to amber yellow: the slime tended to flow and accumulate at the base of the slant. On potato the growth was sulphur yellow

fluid and flowing off the surface but not so abundantly as the slime of *B. Malvacearum* E. F. Smith. Gelatine showed liquefaction under a week and a shallow clear zone formed at the surface of plain and litmus milk after three to four days at 23° C associated with the formation of a bulky indistinct clot apparently due to a lab-enzyme; alkalinity gradually increased becoming strong and persistent and the milk was completely cleared after two to three months of 23° C; the clearing appeared to be caused by peptonisation as no precipitation followed acidification with hydrochloric acid. Growth occurred as a yellow slimy layer on the surface of milk with fat present and absent. The organism was actively motile in young cultures and approximated in size to that of the St. Kitts form.

"The colonies which appeared in platings made from the inoculated canes were not uniform in type; some resembled those of the original culture, but they were as a rule, mingled with others showing a piled-up deeper yellow colour, a dark opaque nucleus, and little tendency to spread; others again were at first flat, but changed to the second type after a few days. Transfers from the different colonies to agar slants yielded, however, a similar pale yellow slimy fluid growth like that of the original form. All cultures from isolations behaved like the original culture in liquefying gelatine appreciably within a week and clotting milk in three to four days at 23° C. with gradually increasing alkalinity and in clearing it eventually but with marked differences in the rate of clearing as cultures from the second or 'piled' up type of colony were slower in action. The isolation from Australia, showed therefore, cultural characters similar to those of the first type from 'gummed' cane in St. Kitts, and it is believed now that they are probably identical. As the cultures made from the isolations out of the different varieties were essentially similar to the two types used for inoculation, and as no evidence was obtained that the one type could change into the other, it would appear that two yellow forms may cause Gummy Disease occurring in some instances together and which differ in cultural characters enough to be considered as distinct varieties of *B. vascularum*. The strain described by Erwin F. Smith resembles the second type from St. Kitts differing from some cultures of it only in not eventually clearing milk, a difference which appears to depend on the amount of alkali produced; the alkaline body is either ammonia or an amine as the vapour from boiling cultures turns red litmus paper blue."

In August, 1930, a gummosis disease was discovered on POJ 2878 at Jayuya, a point located in the center of the island and at an elevation of about 2,000 feet. This was especially interesting because this variety was supposed to be immune or highly resistant.

The cane was sent to the laboratory and put in a moist chamber, where it produced a typical gumming within 24 hours. Owing to the fact that this variety was supposed to be immune, the senior author and Mr. Pedro Richardson, Agronomist, visited Jayuya in order to make sure that it was POJ 2878. After a careful examination, it was decided that there was no doubt as to the variety. The symptoms were not quite typical. However, the gumming was so pronounced that it was detected by the foreman who was making cuttings for planting. The behavior of the organism in culture was typical of *B. vascularum*.

This outbreak was described by the senior authority------------ as follows:

"The cane was about seven months of age from date of planting and the infection was well over 75 per cent.

"The external symptoms were somewhat different from those described by the various writers on the subject. The early symptoms were not found but the late symptoms were very abundant. These symptoms consisted in a dying of the tissues in the leaves along the veins, thus producing elongated areas of dead tissue which frequently extended to the leaf margins. In many cases the margins of the leaves also were dead. When the tops of the canes were cut across, many of them showed a gumming, which was much more pronounced when the cuttings were kept in moist chamber for a few hours.

"The gum was not the typical honey yellow which has been described by several writers, but ranged from clear to creamy white or yellow, and in some cases was slightly tinted with honey yellow."

The further history of this outbreak is as follows:

A field test with healthy P.O.J. 2878, 2883, 2714, 2727, P.R. 801, 803, 807, 809, 820, 826, F.C. 916 and Guadeloupe 119 was started in which every third row was planted with infected P.O.J. 2878, so that every variety of healthy cane was in contact with an infected row. The rows were five feet apart and consisted of 50 stools each. The field of infected cane was plowed out.

At this same time cuttings of the same varieties were set in our greenhouse, and the young canes inoculated with cultures prepared in the laboratory. Some of P.O.J. 2878, 2883, P.R. 807, 809, 826, F.C. 916 and Guadeloupe 119 developed slight symptoms and the organism was recovered from them but in an attenuated form. After a time the new growths failed to produce symptoms and it was impossible to recover the organism.

The field test was cut January 20th, 1932, and carefully examined by the writer. Neither symptoms nor gumming were found in any of the varieties, nor in the rows planted with infected cane. A few canes showed slight discolorations of the fibro-vascular bundles, but no gumming. They were brought to the laboratories and used for cultures. P.O.J. 2883 and F.C. 916 produced a gum organism which is not typical. The color of the gum is greyish, almost clear; some times tinted with yellow.

The greenhouse tests made by the writer with organism from P.O.J–2878 at Jayuya lead the writer to believe that P.O.J.–2878, P.O.J.–2883, P.R.–807, P.R.–809, P.R.–826, F.C.–916 and Guadeloupe 119 may be symptomless carriers although this has not been demonstrated. However, the studies during 1933 show that P.O.J.–2878 when inoculated with an extremely virulent strain of *B. vas-*

cularum will sometime develop leaf symptoms. It is the opinion of the writer that these varieties are so resistant as to be practically immune and that the experiments indicate that it is possible for a very highly resistant or apparently immune variety to be a carrier of this disease.

Cultures for P.O.J. 2878 were sent from Puerto Rico by the writer to Mr. A. F. Bell of Australia for comparison with the Australian organism. He replied as follows:

> "I desire to acknowledge receipt of your letter of 22nd October, also of four cultures. Of the latter three were apparently pure and one contained a yeast. The former were re-isolated and examined and compared with the organism of leaf-scaled, gumming, red stripe, and mottle stripe. Your organism is quite distinct from any of these four.
>
> "Parallel inoculations were made (in the transfer chamber) into cut shoots of Badila and from this small test your organism seemed much more virulent than the above four stains.
>
> "At the end of two days the lesions were about one-fourth inch in diameter and consisted in dark-red rings surrounding a water-soaked greenish or yellowish area. Later the centers became ashy coloured and the red ring surrounded by a yellowish halo.
>
> "I enclose a photograph of the lesions. The cultures and experimental material have now been destroyed. Our experience so far it that P.O.J. 2878 is highly resistant to gumming disease."

The senior author wrote another letter to Mr. Bell making inquiry as to the morphological characters of the Puerto Rican and Australian organisms. He replied (under date of March 30th, 1931) as follows:

> "Your letter of 10th February to hand. With reference to the organism you sent, this was quite distinct from our *B. vascularum* both culturally and morphologically. One considerable difference was that the organism received from you had flagella at both poles while the gumming organism has a singled flagellum only. The organism to which it bore most resemblance was that causing mottle stripe."

An examination of the photograph (Fig. 2) of this organism, made by Mr. Bell, shows that it is quite distinct from *B. vascularum*. The studies by Ashby and by the senior author emphasize the importance of more extensive studies on this disease and its cause or causes in different parts of the world.

1932 Studies

There was a severe outbreak of gummosis on the small island of Vieques in March and April 1932 and slight outbreaks in the vicin-

ity of Río Piedras and Canóvanas. The senior author made a special study of infected Cristalina from the island of Vieques on a very small mixed planting near Canóvanas and on mixed plantings containing Cristalina near Río Piedras during 1932. Vieques is a small island just east of Puerto Rico and has much less rainfall than Puerto Rico. Cristalina has been retained there as the variety of major commercial importance long after it gave way to other varieties in Puerto Rico. It is very susceptible to this disease and the infection is very near to 100 per cent. The rainfall was exceptionally high during the spring of 1932 and the disease was very evident. Most of the cuttings showed a high yield of gum.

Many cultures were made and studied. The results confirmed the opinions of the senior author which were published in 1928. There were many strains which varied in color and character of growth. These results are shown in table I.

TABLE I.

No.	Source	Color	Growth on new cul.	Inoc. 6/20 Symptoms 6/24	June 18th Symptoms	July 1 Symptoms	July 18 Symptoms
1	Australia..........	Yellow ...	Poor......	POJ-2878 none	Crist none..	POJ-2878 none	None
2	Jayuya FC-916......	White	Poor......	POJ-2878 none	Crist none..	POJ-2878 none	None
3	Vieques 6032.......	Canary Yellow	Poor......	POJ-2878 none	Crist none..	POJ-2878 none	None
4	Vieques Crist......	Yellow ...	Good	POJ-2878 none	Crist none..	POJ-2878 none ..	None
5	Vieques...........	Yellow ...	Fair	Very Slight	Crist none..	POJ-2878 none	None
6	Vieques..........	Yellow ...	Good	Good	Good	POJ-2878 none	Slight
7	Vieques...........	Yellow ...	Good	Very Slight.	Very Slight.	Slight	None
8	R. P. Crist..........	Yellow ...	Good.....	Good	Good.......	18 in.	Slight
9	Jayuya POJ-2878..	White	Poor	Very Slight.	Slight	1½ in.....	Slight
10	Vieques...........	White	Good	Slight	Very Slight.	Outgrown	None
11	Vieques...........	Yellow ...	Fair	Slight	None	Outgrown	None
12	R. P. H.—109 slow..	Yellow ...	Fair	Slight	Very Slight.	Outgrown	None
13	R. P. H.—109 slow..	White	Poor	None	Very Slight.	Outgrown	None
14	R. P. H.—109 slow..	White	Poor......	Slight	None	None.....	None
15	R. P. H.—109 slow..	White	Good	Slight	Very Slight.	Outgrown	None

R. P. H.—109 = H 109 from Río Piedras.

The results given in this table confirm the opinion of the senior author expressed in 1928 that this species included a large number of strains which varied in color, growth and virulence.

1933 Studies

The first half of 1933 on Vieques was very dry as compared with 1932. The Cristalina and Rayada (a variety of Cristalina) canes were very heavily infected with *B. vascularum* but the exudation of gum was much less than in 1932. A large number of isolations were made and used for laboratory study. All the cultures used in 1933 were new and from Vieques canes except three: Nos. 1 and 2 were 1932 cultures which had lost their virulence but made excellent growths on agar. No. 23 was a culture sent to the senior author by Mr. A. F. Bell of Brisbane, Australia, late in 1932 and received in January, 1933.

The laboratory studies showed a large number of strains which possessed the following characters:

1. *Color.*—Various shades of yellow and milk white, while others were clear or sometimes clear and slightly tinted with yellow. A few were brownish. In many cases the first growth of a yellowish exudation was white when transferred to agar. Many strains changed color on the agar. The strains were grown on different media and at different pH but up to the present time the changing of colors has not been explained. The best growths were made in acid media but good growths were made on alkaline media as high as pH 9.6 although it was slower than on the acid media. Strains also changed from rough to smooth and smooth to rough without any apparent cause.

The variations in color were in harmony with those reported by the senior author in 1928. Cobb reported variations in color in 1905 but other writers did not give much attention to this phase of the subject. Possibly the material which they were studying did not show the extensive variations which are reported by the authors of this paper.

Some strains were extremely virulent while others were slightly virulent as shown by the leaf symptoms. Others did not produce leaf symptoms but grew in the canes as was shown by the exudations when the canes were cut and kept in a warm, moist chamber.

There was very little relationship between color and virulence although in general it may be said that the yellow strains were slightly more virulent than the others.

No experiments were made to determine temperature relationships but cultures that were put in incubators and refrigerators died in a short time.

Two series of inoculations were made and recorded in Table II. Other inoculations were made but the results were the same as shown in this table.

TABLE II.

No.	Color	
1	Yellow	No infection. Was virulent in 1932.
2	White	No infection. Was virulent in 1932.
3	White	No infection.
4	Almost clear	No infection.
5	White, yellow with age	Mild symptoms on Cristalina.
6	Yellow	Symptoms on Cristalina and H-109.
6	White	Symptoms on Cristalina and H-109.
7	Yellow	Symptoms on Cristalina and H-109 and POJ-2878.
8	White, yellow with age	Not infectious.
9	Clear, brown with age.	Not infectious.
10	White, brown with age	Not infectious.
11	White	Mild symptoms on Cristalina.
12	Whitish, almost clear.	Not infectious.
13	Yellow	Symptoms on Cristalina.
13	White	Symptoms on Cristalina.
14	White	Not infectious.
14	Yellow	Not infectious.
15	White	Very slight symptoms on Cristalina. Developing very slowly.
16	Clear, yellow tint	Mild symptoms on Cristalina and H-109.
17	Clear, yellow tint	Mild symptoms on Cristalina and H-109. Developing very slowly.
17	Yellow	Not infectious.
18	White	Not infectious.
19	White	Symptoms on Cristalina and H-109.
22	White	Symptoms on Cristalina and H-109 and POJ-2878.
23	Yellow	Very mild symptoms on Cristalina.
24	Clear, white tint	Symptoms on Cristalina, H-109 and POJ-2878.
25	White	Symptoms on Cristalina and PR-803.
26	Yellow	Symptoms on Cristalina.
27	Yellow	Symptoms on Cristalina, H-109 and POJ-2878. Very slight symptoms on FC-916.
28	Light yellow	Symptoms on Cristalina, H-109 and very slight symptoms on M-28.
29	White	Symptoms on Cristalina.
30	Yellow (rough)	Symptoms on Cristalina and POJ-2878.
31	Yellow (smooth)	Symptoms on Cristalina. Slight symtoms on PR-803.
32	White	Symptoms on H-109.
32	Clear	Symptoms on Cristalina.
33	White	Symptoms on Cristalina.
34	Yellow	Symptoms on Cristalina.
35	Yellow	Slight symptoms on Cristalina.
36	Yellow	Symptoms on Cristalina.

Nos. 1 to 23 inoculated 5/5/33. Nos. 24, 36, inoculated 5/19/33. Time for appearance of leaf symptoms one to three weeks, occasionally longer. Nos. 1 and 2 were 1932 culture which lost their virulence. No. 23 from Australia. All others were 1933 cultures.

METHODS OF INOCULATIONS

Several methods of inoculation were used as follows:

1. Pricking the cultures into young cane or leaves with a needle. This was successful but slow and the percentage of takes less than with the other methods.

2. Cutting of the tops of the canes almost down to the growing points and the immediate application of the organism in agar. Then covering the mass with a pad of wet cotton. These inoculations were made late in the afternoon so that the agar would remain moist as long as possible. In some cases distilled water was poured on the cotton one or more times during the following day. The inner leaves push upward within 48 hours and if the variety is very susceptible white streaks will be found running downward. Varieties that are practically immune will not show these streaks. Sometimes streaks

three or four inches in length, will develop in highly resistant variety. However, they do not lengthen after the first few days and the organism dies.

3. Cutting a small hole into the spindle above the growing point and the insertion of the organism from an agar culture. Within ten days or two weeks the injured parts of the leaves pushed out and unrolled. The presence of the organism could be determined by the development of white streaks in the leaves running up and down from the point of injury. The variations in time depended on the resistance of the variety and the virulence of the strain in the culture.

4. The inoculation of the organism from agar cultures into the stem below the growing point. This method was successful but slow. A high percentage of gum pockets resulted.

5. Removing the upper half of an advanced cane so as to force the development of side shoots. When the side shoots are well advanced cut holes in the old cane and insert agar containing the organism.

6. The insertion of pieces of diseased cane into slits in the spindle or cane. The results were practically the same as when agar cultures were used but more uncertain.

7. Inoculation of seed cuttings by the insertion of the organism from cultures in holes cut in the seed pieces. This method was slow and the results irregular.

The results of the inoculations not given in the Table II may be summarized as follows:

Rapid-growing canes respond to inoculations much more readily than slow-growing canes.

Canes inoculated with a culture may show negative results at one time and mild symptoms at another time. The symptoms may develop more slowly in some cases than in others although the inoculations are made from a single culture and on one variety. Some strains do not produce leaf symptoms but do produce gum in the canes and in cultures.

When an infected cane is cut across and placed in a warm, moist chamber, the gum oozes out on the cut surfaces, sometimes in such great abundance as to cover the entire cut area. Two or more colors may emerge from a single piece. When the gum is transferred to agar plates, it makes a very rapid growth. Sometimes all the colors persist and sometimes the deep yellow makes a clear growth. Some of the clear growths from yellow gum become yellow later and some remain yellow. The yellow strains show a great tendency to produce modifications of yellow and sometimes become clear or white. Some

strains grow much more luxuriantly than others. Some strains are much more virulent than others. Some strains that produce gum in the cane and in culture do not produce leaf symptoms. Positive results may be obtained from cultures of all colors and all tints but in general the yellows are more virulent than the other colors.

Bacteriological Study

Twenty-seven cultures collected in 1932 and previous to that date were studied and classified as follows:

Group I.—Is composed of five cultures isolated from the island of Vieques. They produced an abundant canary-yellow growth in twenty-four hours. They are bacilli arranged parallel and side to side, motile and show no spores nor capsules. The colonies are homogeneous, entire edged, straw in color, stain negative to Gram, growth in broth is turbid, agar stroke is slow, confluent, smooth, viscid and opaque and show no change in litmus milk. It does not ferment dextrose, lactose, dulcite, manite, maltose, sucrose, xylose or arabinose; does not produce hydrogen sulphide nor indol; the V.P. and M.R. reactions are negative; does not reduce nitrates, has no odor and emulsify very poorly. This group of organisms is identical with the cultures of *B. vascularum* isolated in Australia that we had previously studied.

Group II.—This group consisted of twelve cultures isolated from "Cristalina" cane in Vieques and from "F.C.–916" cane in Jayuya. Some produced a whitish-gray growth while others had a lemon-yellow growth. They are bacilli arranged side by side, parallel or end to end, motile, have no spores nor capsules. The colonies are homogeneous, entire edged, and straw in color. They are negative to Gram stain, grow slowly in broth with slight turbidity. In agar the growth is slow, confluent, raised, smooth, viscid and opaque. There is no change in litmus milk, no acid is produced in arabinose, xylose, dextrose, lactose, dulcite, manite, maltose and sucrose. They produce no hydrogen sulphide and no indol; the V.P. and M.R. reactions are negative; they do not reduce nitrates, do not produce any odor and have a poor emulsificability.

Group III.—Is composed of ten cultures isolated from "P.O.J.-2878" at Jayuya and "Cristalina" cane from Vieques. The growth of some of the cultures is absolutely colorless and in others is enamel white. They are bacilli which are found singly or in short chains, motile, form no spores nor capsules and are negative to Gram stain. The colonies are granular, straw in color and have entire edge. The

growth in broth is slight turbid with filament and at times a ring adherent to the tube is formed. The agar stroke is filiform, elevated, smooth and translucent or white. They do not ferment dextrose, maltose, manite, xylose, sucrose, arabinose or dulcitol; they do not produce hydrogen sulphide and the V.P. and M.R. reactions are negative. They do not reduce nitrates, have no odor and have poor emulsificability.

The cultures studied differ in pigment production but their sugar fermentations are similar. In 1933, eighteen cultures have been studied, ranging in color from yellow, white, creamy, lemon-yellow, grayish white to colorless. Thirteen of the cultures are bacteriologically similar to the description given in Group I of the 1932 cultures, that is, they are Gram negative organisms, motile, do not ferment any of the sugars tested, do not produce hydrogen sulphide, have no change in litmus milk, do not produce indol, do not reduce nitrates, the V.P. and M.R. reactions are negative, they have no odor and have very poor emulsificability.

TABLE III.

FERMENTATION REACTION, 1933 CULTURER.

Culture B	Isolated from	Color	Glucose	Manite	Lactose	Xylose	Saccharose	Maltose	Dulcite	Arabinoses
23	Australian culture...	Yellow	.....	.....	.....	.....	.....	.....	.....	.....
24	Cristalina	White	.....	.....	.....	.....	.....	.....	.....	.....
25	Cristalina	White	.....	.....	.....	.....	.....	.....	.....	.....
26	Cristalina............	White	+	+	.....	+	+	+	+	+
27	Cristalina....	Yellow	.....	.....	.....	.	.....	.....	.....	.....
28	Cristalina......	Creamy yellow...	.....	.....	.....	.....	.....	.....	.....	.....
29	Cristalina...........	White	.....	.....	.....	.....	.....	.....	.....	.....
30	Cristalina............	Creamy yellow...	.....	.....	.....	.....	.....	.....	.....	.....
31	Cristalina	Creamy yellow...	.....	.....	.....	.....	.....	.....	.....	.....
32	Cristalina............	Colorless.........	.....	.....	.....	.....	.....	.....	.....	.....
32 c	Cristalina	Yellow	.....	.....	.....	.....	.....	.....	.....	.....
33	Cristalina............	White	+	+	.....	+	+	+	+	+
34	Cristalina	Yellow	.....	.....	.....	.....	.....	.....	.....	.....
35	Cristalina............	Grayish white....	.....	.....	.....	.....	.....	.....	.....	.....
36	Cristalina	Grayish white....	.....	.....	.....	.....	.....	.....	.....	.....
37	Cristalina............	White	+	+	.....	+	+	+	+	+
38	Cristalina	Yellow	+	+	.....	+	+	+	+	+
39	Cristalina............	White	+	+	.....	+	+	+	+	+

There are five cultures labeled 26, 33, 37, 38 and 39 which range from white to yellow color and which are absolutely different from the others macroscopically. They are bacilli arranged singly, motile, form no spores nor capsules. The colonies are finely granular, straw in color and entire edged. They are Gram negative. The growth in broth is heavy and granular; agar stroke is filiform, elevated, smooth and whitish in color. They produce slight acidity and coagulation in milk. They produce acid and gas in glucose, manite, xylose,

sucrose, maltose, dulcite and arabinose. They do not ferment lactose. They produce hydrogen sulphide; indol is negative; V.P. and M.R. reactions are negative; they have no odor and emulsify very poorly. These cultures produce a gummy substance but it is still questionable to our mind if they produce true gummosis.

SEROLOGICAL

Two rabbits were inoculated intravenously with cultures 32 c and 33, respectively, and two potent antisera were obtained. By direct agglutination cultures 23, 24, 25, 27, 28, 29, 30, 31, 32 and 32 c, 34, 35 and 36 agglutinated to different titers with antiserum 32 c, while they did not agglutinate at all with antiserum 33. The same was true of cultures, 33, 26, 37, and 39, which agglutinated with antiserum 33, but did not agglutinate at all with antiserum 32 c. This demonstrates that 13 cultures are antigenically alike, one of these strains, 23, being a known gummosis strain isolated from Australia. The other five cultures, i.e., 33, 26, 37, 38 and 39, are antigenically different from the first 13 cultures studied.

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The authors wish to express thanks to Mr. Arturo Riollano for making frequent shipments of diseased cane to the senior author, and to the following workers in the United States Department of Agriculture for hearty cooperation; to Dr. E. W. Brandes, to Mrs. Starrett and Miss Katherine Bryan for making micro-preparations and for photographing, and to Mr. Brewer and Dr. Astchwager for making photographs of the organism. Also to Mr. Arthur F. Bell, of the Bureau of Sugar Experiment Stations of Brisbane, Australia, for sending cultures and photographs for study.

LITERATURE

(Published since 1927)

1. **Ashby, S. F.** Notes in the Report of the Agricultural Department of Dominica. 1928–29.
2. **Ashby, S. F.** Gumming Disease of Sugar Cane. Tropical Agriculture. **6**: 135–138. (1929).
3. **Ballou, H. A.** Report of the Agricultural Department. St. Kitts–Nevis 1926–27. Page 3. Also 1927–28, page 4.

4. **Bell, A. F.** Records in the 29th Annual Report of the Bureau of Sugar Experiment Stations. 1929.
5. **Cook, Melville T.** The Gummosis of Sugar. The Journal of the Department of Agriculture of Puerto Rico. **12**: 143–179 (1928).
6. .... The Gummosis of Sugar Cane (second paper). The Journal of the Department of Agriculture of Puerto Rico. **13**: 73–76. (1929).
7. .... Gummosis of P.O.J.–2878 Cane in Puerto Rico. Facts about Sugar, **26**: 257. (1931).
8. .... The Gummosis of Sugar Cane. International Society of Sugar-Cane Technologists. Bull. **35**: 1–2. (1932).
9. .... **et at.** Report on the International Survey of the Diseases of Sugar Cane. International Society of Sugar-Cane Technologists. Bulletin **28**: 1–15. 1932.
10. **Illingworth, J. L.** Notes on Gumming Disease of Sugar Cane. Bulletin of the Leeward Island Department of Agriculture. (1930.)
11. **Martin, J. P.** Gumming Disease of Sugar. The Hawaiian Planters' Record. **34**: 65–78. (1930.)
12. **North, D. S.** Gumming Disease in Cane Field. (A lecture.) (1925.)
13. .... The Sugar Industry Problems of Grower. (A lecture.) (1928.)
14. .... The Bacterial Disease of Sugar Cane. Facts about Sugar. **24**: 800–881. (1929.)
15. .... Obtaining Resistant Cane Varieties for the Control of Gumming Disease. International Society of Sugar-Cane Technologists. Bull. **30**: 1–3. (1932.)
16. **Williams, H.** La Gommosi a la Guadeloupe. The Journal de la Station Agronomique de la Guadeloupe. **7**: 106–111. (1929.)
17. Report of the Federal Agricultural Department Laboratory for the Leeward Islands. 1929–30. Page 5.

Explanation of Plates

The photographs were not made on the same scale but the measurements were practically the same in all cases.

Fig. 1.—*B. vascularum.* Photographed by W. Cottrell-Dormer of the Bureau of Sugar Experiment Stations, Brisbane, Australia.

Fig. 2.—The organism from the gumming cane (P.O.J.–2878) at

Jayuya, Puerto Rico. Photographed by A. F. Bell, of the Bureau of Sugar Experiment Stations, Brisbane, Australia, from a culture sent to him by the senior author.

FIG. 3.—*B. vascularum* from white culture from Cristalina from Vieques.

FIG. 4.—*B. vascularum* from yellow culture from Cristalina from Vieques.

NOTE.—Numbers 3 and 4 photographed by Mr. Brewer and Dr. Artschwage of the U. S. Department of Agriculture.

PLATE XXI

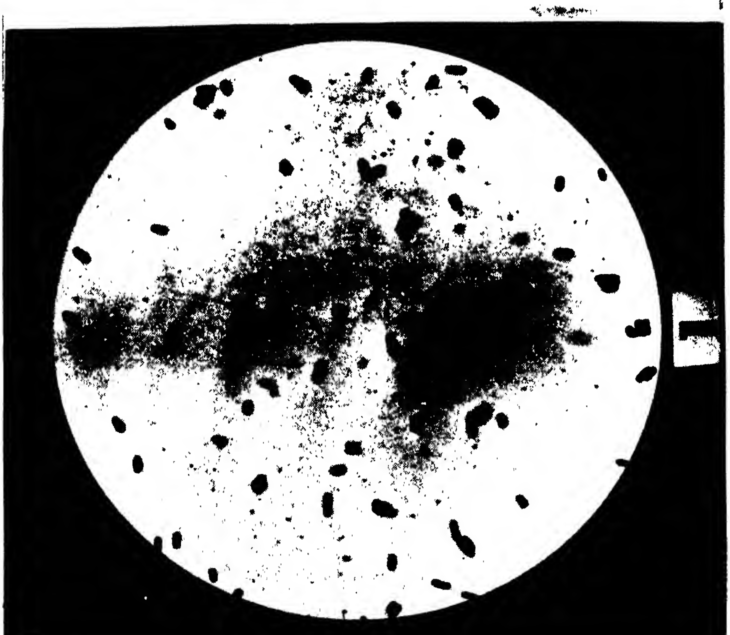

PLATE XXII

RESEARCH ON SHORTENING TIME WITHOUT AFFECTING THE ACCURACY OF DYER'S MODIFIED METHOD FOR THE DETERMINATION IN SOILS, OF PHOSPHORIC ACID, LIME AND POTASH SOLUBLE IN CITRIC ACID SOLUTION (1 PER CENT)

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Since the soil survey of Puerto Rico started in 1928 under the joint cooperation of the U. S. Bureau of Chemistry and Soils and the P. R. Insular Experiment Station, the soil samples sent by the field staff have been analyzed for phosphoric acid, lime and potash soluble in 1 per cent citric acid solution. Before this research was undertaken as one of the projects of the new Soils Division officially created in June 1931, the method used was as follows:

DYER'S MODIFIED METHOD (3)

"Place 100 grams of the air dried soil sample in a Winchester acid bottle. Add 1 liter of a 1 per cent citric acid solution. Shake in a shaking machine 6 hours. Let stand overnight to clear. Filter off about 700 cc of the clear supernatant liquid through a double filter paper. Evaporate exactly 500 cc nearly to dryness in a 600 cc beaker on the hot plate, then transfer the resulting dark colored solution to a platinum dish (using hot water) and evaporate to dryness on a water bath. Completely dry the sticky residue (2 hours in a hot air oven at a temperature of about 120° C.).

"Ignite the residue in the platinum dish in a muffle at low temperature (dull redness) for about 2 hours to remove organic matter. The char should now be gray in color. Moist with con. HCl, add a little hot water and evaporate to dryness on the water bath. Leave on water bath at least 1 hour to dehydrate any silicic acid still remaining as such. Take up in a little con. HCl; add a little water; heat one-half hour on a water bath; add more hot water and filter. Wash five times with hot water slightly acidified with HCl; make up to at least 300 cc with hot water. To the clear filtrate add 2 or 3 cc of con. HNO_3 and boil 15 to 20 minutes to oxidize all organic matter in solution. Precipitate Fe, Al, Ti and P_2O_5 with NH_4OH in

hot solution, filter and wash free from chlorides with hot water. In case of insufficient Fe to color the solution slightly brown, add a few cc of a 10 per cent $FeCl_3$ solution before precipitation. (This is to insure complete ppt. of P_2O_5.)

Phosphoric Acid, P_2O_5

"Dissolve the above ppt. in dil. HNO_3 and boil. Cool slightly, *nearly* neutralize with NH_4OH add 5 grm. NH_4NO_3 and ppt. P_2O_5 with 25 cc molybdate sol. at 65° C. Let stand 20 min. at 65° then let cool. Filter through asbestos, thoroughly wash and det. P_2O_5 volumetrically.

Lime, CaO

"Evaporate down to 150 cc the filtrate from Fe and Al, make very slightly alkaline with NH_4OH and ppt. Ca as oxalate with ammonium oxalate in hot solution. Let stand on the water bath 1 hour then cool over night. Filter, wash with cold water, dissolve in H_2SO_4 (1 to 5 by vol.) and titrate with a standard $KMnO_4$.

Potash, K_2O

"Acidify filtrate from Ca slightly with dil. H_2SO_4. Evaporate to dryness in a beaker, transfer to platinum dish and run to dryness. Carefully ignite off excess of H_2SO_4 and all ammonium salts over a free flame; take up residue with hot water, filter into porcelain evap. dish and add 2 or 3 drops of dil. HCl and sufficient platinic chloride sol. to ppt. all the potassium. Evaporate nearly to dryness, filter, wash and weigh as potassium platinic chloride in the usual gravimetric way."

Experimental

The modified procedures introduced have been as follows:

Place 150 grams of the air dried soil sample in a Winchester acid bottle. Add 1500 cc of a 1 per cent citric acid solution. Shake in a shaking machine, 6 hours. Let stand overnight to clear. Filter.

Phosphoric Acid, P_2O_5

Measure in a beaker, 500 cc of the filtered citric acid extract. Add 10 cc HNO_3 and 30 cc HCl. Evaporate in hot plate, nearly to dryness. Transfer to evaporating dish and dry residue carefully, in sand bath. Ignite the residue at low temperature to destroy the un-

decomposed organic matter and complete the dehydration and destruction of silicates. Dissolve in 5 cc HNO_3 and 15 cc HCl, dilute with water and filter. Follow official molbydate volumetric method. (If a brown color due to manganese persists in the solution after neutralizing with NH_4OH and acidifying with HNO_3, heat to coagulate the colloidal suspension and filter.)

Lime, CaO

Measure in a beaker, 100 cc of the filtered citric acid extract. Determine lime by Chapman's (4) method as follows:

To the solution containing Ca, Mg, Mn, Fe, Al, Ti, and P_2O_5 add about 6 grams of NH_4Cl. One gram of oxalic acid in solution, 10 cc of 1.76 normal acetic acid, and 10 drops of .04 per cent brom cresol green, are added. The solution is made to a volume of about 200 cc and brought nearly to boiling. Dilute ammonia is added slowly until a drop of the solution added to a drop of brom cresol green in a porcelain spot plate changes from yellow thru yellowish green to the first pure green (pH3.9–4.2). The solution is then boiled gently for five minutes, the calcium precipitating in a coarse crystalline state. The precipitate is then allowed to stand on a steam bath until it wholly subsides. Allow the solution to cool before filtration. Wash five times with cold water. Determine CaO by the official permanganate volumetric method.

Potash, K_2O

Evaporate 500 cc of the filtered extract nearly to dryness, on the hot plate. Transfer the resulting dark colored solution to a silica dish (using hot water) and carefully evaporate to dryness on a sand bath. Ignite the residue in a muffle to about 1000° F. (incipient red heat) for about 2 hours to remove organic matter. Add 15 cc HCl, add a little hot water and evaporate to dryness on the water bath. Take up in 5 cc of HCl and water, heat for 30 minutes on a water bath; add more hot water and filter. Wash three times with hot water and make up to about 200 cc. To the clear filtrate add 2 cc of HNO_3 and boil 10 minutes to oxidize all organic matter in solution. In hot solution, precipitate Fe, Al, Ti and P_2O_5 with NH_4OH adding also 25 cc of saturated ammonium oxalate solution to precipitate Ca and Mg. Filter and wash well with hot water. (In case of insufficient Fe to color the solution slightly brown, add a few cc of a 10 per cent $FeCl_3$ solution before precipitation. This is to insure complete precipitation of P_2O_5.)

To filtrate add 2 cc H_2SO_4 (1:1) and evaporate to dryness in sand bath. (It is convenient to add 5 cc of HNO_3 before evaporating to dryness to avoid losses due to the creeping out of the salts.) Ignite to whiteness to expel ammonium salts. Extract with hot water and filter. Determine K_2O by the official Lindo-Cladding method.

Analytical Results of Percent CaO by Chapman's Method

Comparative values by Student's method of percent CaO as determined by Dyer's modified and Chapman's methods are expressed in table I. To eliminate personal error, all analyses by both methods were performed in the same extraction by the same chemist, F. A. Villamil. The letters A or B following a sample number represent duplicate extractions. The values in columns A and B represent percent CaO obtained respectively, by the Dyer modified method and by the Chapman method. The values of column (A–B) are obtained by subtracting the values of column B from those of A. The factor .9702 was obtained by dividing the total of column A by that of B. The values of column C are obtained by multiplying that factor by the values of column B. The values of column (A–C) are obtained by subtracting the values of column C from those of A. The values D and D^1 represent mean deviations. The standard deviation of the mean of column (A–B) is obtained by the formula:

$$S.\ D. = \sqrt{\frac{SmD^2}{n(n-1)}}$$

where SmD^2 is the sum of the values D^2 and n, the number of observations. The standard deviation of the mean of column (A–C) is obtained by that same formula substituting $Sm(D^1)^2$ for SmD^2.

The value Z represents the ratio of the mean of column (A–B) to the square root of the mean of the values D^2. The value (Z^1) represents the ratio of the mean of column (A–C) to the square root of the mean of the values $(D^1)^2$. The statistical interpretation of the results was obtained with values Z and n in the Student's table modified by Love (9), n = 91 in this case.

TABLE I.

COMPARATIVE VALUES BY STUDENT'S METHOD OF PERCENT CaO AS DETERMINED BY DYER'S MODIFIED AND CHAPMAN'S METHODS.

No.	Dyer's A % CaO	Chapman's B % CaO	A—B	D (A-B+.014)	D^2	C (.9702B)	A—C	D' (A—C—.0004)	$(D')^2$
1	.266	.288	—.022	—.008	.000064	.279	—.013	—.0134	.00017956
2	.697	.731	—.034	—.020	.000400	.709	—.012	—.0124	.00015376
3	.241	.260	—.019	—.005	.000025	.252	—.011	—.0114	.00012996
4	.118	.126	—.008	.006	.000036	.122	—.004	—.0044	.00001936
5	.084	.118	—.034	—.020	.000400	.114	—.030	—.0304	.00092416
6	.051	.064	—.013	.001	.000001	.062	—.011	—.0114	.00012996
7	.518	.529	—.011	.003	.000009	.513	.005	.0046	.00002116
8	.065	.070	—.005	.009	.000081	.068	—.003	—.0034	.00001156
9	.081	.095	—.014	0	0	.092	—.011	—.0114	.00012996
10	.868	.958	—.090	—.076	.005776	.929	—.061	—.0614	.00376996
11	.110	.137	—.027	—.013	.000169	.133	—.023	—.0234	.00054756
12	.087	.098	—.011	.003	.000009	.095	—.008	—.0084	.00007056
13	.378	.403	—.025	—.011	.000121	.391	—.013	—.0134	.00017956
14	.079	.084	—.005	.009	.000081	.081	—.002	—.0024	.00000576
15	.171	.168	.003	.017	.000289	.163	.008	.0076	.00005776
16	.266	.314	—.048	—.034	.001156	.305	—.039	—.0394	.00155236
17	.952	.960	—.008	.006	.000036	.931	.021	.0206	.00042436
18	.554	.596	—.042	—.028	.000784	.578	—.024	—.0244	.00059536
19	.137	.151	—.014	0	0	.147	—.010	—.0104	.00010816
20	.129	.154	—.025	—.011	.000121	.149	—.020	—.0204	.00041616
21	.224	.238	—.014	0	0	.231	—.007	—.0074	.00005476
22	.756	.795	—.039	—.025	.000625	.771	—.015	—.0154	.00023716
23	.286	.305	—.019	—.005	.000025	.296	—.010	—.0104	.00010816
24	.244	.252	—.008	.006	.000036	.244	0	—.0004	.00000016
25	.594	.605	—.011	.003	.000009	.587	.007	.0066	.00004356
26	.532	.546	—.014	0	0	.530	.002	.0016	.00000256
27	.644	.650	—.006	.008	.000064	.631	.013	.0126	.00015876
28	.487	.504	—.017	.003	.000009	.489	—.002	—.0024	.00000576
29	.616	.622	.006	.008	.000064	.603	.013	.0126	.00015876
30	.305	.314	—.009	.005	.000025	.305	0	—.0004	.00000016
31A	.064	.067	—.003	.011	.000121	.065	—.001	—.0014	.00000196
31B	.064	.067	—.003	.011	.000121	.065	—.001	—.0014	.00000196
32	.599	.602	—.003	.011	.000121	.584	.015	.0146	.00021316
33	.160	.165	—.005	.009	.000081	.160	0	—.0004	.00000016
34	.132	.134	—.002	.012	.000144	.130	002	.0016	.00000256
35	.269	.274	—.005	.009	.000081	.266	.003	.0026	.00000676
36	1.310	1.330	—.020	—.006	.000036	1.290	.020	.0196	.00038416
37	.089	.087	.002	.016	.000256	.084	.005	.0046	.00002116
38A	.692	.700	—.008	.006	.000036	.679	.013	.0126	.00015876
38B	.694	.703	—.009	.005	.000025	.682	.012	.0116	.00013456
39A	.694	.683	.011	.025	.000625	.663	.031	.0306	.00093636
39B	.689	.686	.003	.017	.000289	.666	.023	.0226	.00051076
40A	.644	.647	—.003	.011	.000121	.628	.016	.0156	.00024336
40B	.641	.652	—.011	.003	.000009	.633	.008	.0076	.00005776
41A	.549	.554	—.005	.009	.000081	.537	.012	.0116	.00013456
41B	.543	.548	—.005	.009	.000081	.532	.011	.0106	.00011236
42A	.196	.246	—.050	—.036	.001296	.239	—.043	—.0434	.00188356
42B	.196	.241	—.045	—.031	.000961	.234	—.038	—.0384	.00147456
43A	.440	.448	—.008	.006	.000036	.435	.005	.0046	.00002116
43B	.428	.454	—.026	—.012	.000144	.440	—.012	—.0124	.00015376
44A	.836	.853	—.017	—.003	.000009	.842	—.006	—.0064	.00004096
44B	.853	.858	—.005	.009	.000081	.847	.006	.0056	.00003136
45A	2.128	2.134	—.006	.008	.000064	2.070	.058	.0576	.00331776
45B	2.122	2.139	—.017	—.003	.000009	2.075	.047	.0466	.00217156
46A	.428	.437	—.009	.005	.000025	.424	.004	.0036	.00001296
46B	.423	.426	—.003	.011	.000121	.413	.010	.0096	.00009216
47A	.235	.246	—.011	.003	.000009	.239	—.004	—.0044	.00001936
47B	.224	.235	—.011	.003	.000009	.228	—.004	—.0044	.00001936
48A	.333	.336	—.003	.011	.000121	.326	.007	.0066	.00004356
48B	.333	.336	—.003	.011	.000121	.326	.007	.0066	.00004356
49A	.126	.154	—.028	—.014	.000196	.149	—.023	—.0234	.00054756
49B	.157	.149	.009	—.023	.000529	.144	.013	.0126	.00015876
50	.700	.706	—.006	.008	.000064	.685	.015	.0146	.00021316
51	.655	.700	—.045	—.031	.000961	.679	—.024	—.0244	.00059536
52	.865	.888	—.023	—.009	.000081	.862	.003	.0026	.00000676
53	.784	.792	—.008	.006	.000036	.768	.016	.0156	.00024336
54	1.123	1.212	—.089	—.075	.005625	1.176	—.053	—.0534	.00285156
55	.073	.064	009	.023	.000529	.062	.011	.0106	.00011236
56	.081	.095	—.014	0	0	.092	—.011	—.0114	.00012996
57A	.591	.599	—.008	.006	.000036	.581	.010	.0096	.00009216
57B	.594	.602	—.008	.006	.000036	.584	.010	.0096	.00009216
58A	.406	.412	.006	.008	.000064	.400	.006	.0056	.00003136
58B	.420	.428	—.008	.006	.000036	.415	.005	.0046	.00002116

TABLE I.

COMPARATIVE VALUES BY STUDENT'S METHOD OF PERCENT CaO AS DETERMINED BY DYER'S MODIFIED AND CHAPMAN'S METHODS—Continued.

No.	Dyer's A % CaO	Chapmans B % CaO	A − B	D (A-B+.014)	D²	C (.9702B)	A—C	D' (A—C—.0004—)	(D')²
59A	.409	.412	—.003	.011	.000121	.400	.009	.0086	.00007396
59B	.406	.409	—.003	.011	.000121	.397	.009	.0086	.00007396
60A	.185	.193	—.008	.006	.000036	.187	—.002	—.0024	.00000576
60B	.179	.188	—.009	.005	.000025	.182	—.003	—.0034	.00001156
61A	.428	.431	—.003	.011	.000121	.418	010	.0096	.00009216
61B	.428	.431	—.003	.011	.000121	.418	.010	.0096	.00009216
62A	.140	.140	0	0	0	.136	.004	.0036	.00001296
62B	.140	.137	.003	.017	.000289	.133	.007	.0066	.00004356
63A	2.078	2.108	—.030	—.016	.000256	2.045	.033	.0326	.00106276
63B	2.078	2.108	—.030	—.016	.000256	2.045	.033	0326	.00106276
64A	.081	.104	—.023	—.009	.000081	.101	—.020	—.0204	.00041616
64B	.092	.109	—.017	—.003	.000009	.106	—.014	—.0144	.00020736
65	.107	.118	—.011	.003	.000009	.114	—.007	—.0074	.00005476
66	.132	.134	—.002	.012	.000144	.130	.002	0016	.00000256
67	.196	.202	—.006	.008	.000064	.196	0	—.0004	.00000016
68	.362	.370	—.008	.006	.000036	.359	.003	.0026	.00000676
69	.070	.070	0	0	0	.068	.002	.0016	.00000256
70	118	.118	0	0	0	114	.004	.0036	.00001296
Sum.	40.752	42.005	−1.253		.025531	40.748	.004		.00307738
Mean	.448	.462	—.014		.00028		.0004		.00034

$$Z = \frac{.014}{\sqrt{.00028}} = .82$$

Odds over 9999:1

$$Z' = \frac{.0004}{\sqrt{.00034}} = .022$$

Odds below 2:1

When both methods are statistically compared, Z=.82 and the odds from the table (9) are found to be over 9999:1. The odds indicate a real difference in the analytical results between the two methods; since according to the table odds over 21:1 indicate a significant difference in the results.

The evidence suggests that Chapman's method tends to give higher results with a mean deviation of .014 per cent ± .0017 per cent in 91 determinations or values that may fluctuate between .0123 per cent and .0157 per cent. For comparison purposes the results obtained by either method may be considered entirely satisfactory. That either is as good as the other is corroborated by the excellent checks obtained by each method in the duplicate of different extractions for samples 31, 38–49 inclusive, and 57–64 inclusive. The statistical interpretation, therefore, does not invalidate at all, Chapman's method.

Chances for personal analytical error are much less in the Chapman method since the work is greatly facilitated by the elimination of the cumbersome procedure required for the precipitation of Al, Ti, and P_2O_5 with NH_4OH in the Dyer modified method. The former method saves about 66 per cent of the time required by the latter.

Were it necessary to convert results obtained by Chapman's

method to those in terms of the Dyer modified method, it would be proper to multiply by the factor .9702. The value Z^1, after the application of such a factor to each result obtained by Chapman's method becomes .022, and the odds from the table are found to be below 2:1. The odds indicate that there is no significant difference between the analytical results of both methods. Results indicate that the increase by Chapman's method tends to be constant. The mean deviation becomes now, .0004 per cent $\pm$ .0017 per cent or a fluctuation between —.0013 per cent and .0021 per cent which is extremely low.

Colorimetric Methods for Phosphoric Acid

Studies were made of the molybdate blue method with the modifications of Briggs and Doisy applied by Arrhenius (**1**) to citric acid extracts. The method is as follows:

"Ten cc of the citric acid extract are placed in a 100 cc volumetric flask and diluted to about 80 cc; 1 cc con. H_2SO_4, 5 cc ammonium molybdate (25 gms. ammonium molybdate dissolved in 300 cc. water) and then 200 cc dilute sulphuric acid (75 cc conc. H_2 SO_4 filled up to 200 cc with water), 1 cc sodium sulphite (20 g. Na_2SO_3 + 80 cc water), and 1 cc hydroquinone (0.5 g. per 100 cc and one drop conc. sulphuric acid), are added. The flask is filled to the mark and the solution shaken. The color is, after 12 to 24 hours, compared with a standard series of solutions with known P_2O_5 content varying between .05 and .90 mgm. P_2O_5 per 100 cc." The so-called Arrhenius molybdate blue method for P_2O_5 determinations in citric acid extract is based on the one recommended by Bell-Doisy-Briggs (**2**) for P_2O_5 determinations in urine and blood, with the exception that the addition of trichloracetic acid for the precipitation of protein material is eliminated.

Although Arrhenius claims that results obtained are accurate below 0.50 mgm. P_2O_5 (.05 per cent P_2O_5 in the 10 cc citric acid aliquot used by us), our results were entirely inconsistent. The citrate ion colored by the presence of iron salts causes difficulty in matching the colors of the unknown and the standard in the colorimeter.

Studies were made of the method that Warren and Pugh (**11**) worked out at the Rothamsted Experimental Station based on the colorimetric determination of phosphoric acid in citric acid extractions of soils as follows:

"Seventy-five cc of the citric acid extract are pipetted into a 300 cc Kjeldahl flask, 10 cc conc. HCl added and followed by 12 cc of 20 per cent sodium permanganate. The sides of the flask are washed

down with a little water. After standing half an hour the contents are vigorously digested till no manganese precipitate remains (about ½ hr. more). The contents are transferred with a minimum amount of water to a 100 cc graduated flask; 4 cc of 10 per cent potassium ferrocyanide are added slowly, drop by drop, with frequent shaking. Several minutes later the mixture is titrated with 1:1 ammonia until the blue color just turns purple; 1.5 cc 2 N sulphuric acid are then added and made to the mark with water. After the solution has been filtered and the first few cc discarded, the color is developed in an aliquot by one of the following methods:

Fiske—Subbarrow (6) "10 to 50 cc are pipetted into a 100 cc graduated flask, diluted to 75 cc approximately, 10 cc of ammonium molybdate added, then 4 cc aminonaphthol sulphonic acid solution and the liquid made to the mark. The flask should be shaken during each addition. The contents are finally poured into a 100 cc conical flask; 15 minutes later the test compared with a standard phosphate solution".

Deniges (5)—"1 to 25 cc are pipetted into a 100 cc graduated flask, diluted to 90 cc, and 1 cc ammonium molybdate and three drops of stannous chloride solution added, the flask being shaken with each addition. After diluting to the mark the contents are poured into a 100 cc conical flask, and compared after 5 minutes with a standard phosphate solution".

Our results with the Warren and Pugh method were extremely low compared with those obtained by the usual Dyer method. This may be due to the adsorption of phosphates by the manganese ferrocyanide precipitate. Ward (10) states that "the ferrocyanide precipitate is difficult to filter, because of its colloidal condition and that the amount of phosphorous present in the sodium permanganate is of the same order of magnitude as that in the sample, and inaccurate results are certain to follow in the case of soils low in P_2O_5".

Lonstein (8) applied the method of Deniges, so widely used for water extracts, to citric acid extracts of a number of South African soils and obtained good agreement with the gravimetric method. His method briefly consists in evaporating a small volume of the citric acid extract to dryness after the addition of calcium acetate solution. The residue is ignited to destroy the organic matter and to render the silica insoluble, and then extracted with 10 per cent sulphuric acid. After filtration the excess of the acid is neutralized with ammonia and the color developed with ammonium molybdate and stannous chloride solutions.

Although we were favorably impressed by the Lonstein method we disregarded it because the figures obtained with it by Warren and Pugh (11) "reveal the presence of some disturbing factor in the analyses of the heavier soils used, especially when the Deniges method

of color production was used. The blue color developed slowly and had a green tint. The view was sustained that the sulphuric acid extracts from the clay soils contained appreciable amounts of ferric iron as the interfering constituents".

One of the latest contributions to the subject on the colorimetric determination of phosphorus in citric acid extracts of soils is the work of Ward (**10**), chemist of the Experiment Station of the Hawaiian Sugar Planters' Association. Ward's procedure for the preparation of the citric acid extract is as follows: "To 100 ml. of citric acid extract, add 50 ml. of concentrated nitric acid, 15 ml. of concentrated hydrochloric acid, and 10 ml. of 20 per cent sulfuric acid free from phosphorus and arsenic. Evaporate slowly till fumes of SO_3 are evolved. Take up in hot water and boil". The iron is removed by electrodialysis into a special electrolytic cell. The color is developed by the method of Zinzadze as follows: "Aliquots from the solutions of citric acid extract prepared for analysis are neutralized to the yellow end point of alpha—dinitrophenol indicator with 10 per cent ammonia solution. Dilute the solutions to 90 ml., add 1.4 ml. of molybdenum blue reagent (molybdic acid reduced by molybdenum metal in sulphuric acid solution), heat for 30 minutes on the steam bath, cool, and make up to exactly 100 ml. Employ a sensitive colorimeter for comparison with the standard solution".

The work of different investigators reveal that the accurate colorimetric determinations of phosphoric acid in soils extracted with 1 per cent citric acid, demands attention on the destruction of the citrate ion, and of the soluble silicates and organic matter; the absence of large amounts of silica; the absence of phosphorous in the chemical reagents used; the elimination of the ferric ion; and a controlled acidity. Ward (**10**) calls the attention to the presence of titanium and to the use of colorimetric standards which are very close to the unknown in color intensity so as to reduce errors due to deviations from Beer's (**12**) law.

Treatments of the Citric Acid Extracts for the Phosphoric Acid Determinations

In view of the several difficulties that we encountered in obtaining accurate results with the application of colorimetric methods for the determinations of phosphoric acid in soils extracted with 1 per cent citric acid we proceeded to study the simplification of the chemical treatments given to such extracts in the Dyer modified method and then followed the official molybdate volumetric method for phosphoric acid.

Our first attempt was to precipitate directly phosphoric acid as ammonium phosphomolybdate in aliquots of the citric acid extracts. In some cases, good checks were obtained with the results by the Dyer modified method. In other cases, no precipitate was obtained; and in other cases, lower results were obtained. This may be explained on the basis that citric acid, extracts from certain soils, phosphates in organic combinations that are not precipitated by ammonium molybdate, and that the presence of the undecomposed soluble silicates may hold by absorption the phosphate ions in solution.

Our second attempt was to destroy the organic and silicate compounds by evaporation almost to dryness, with aqua regia. The residue was taken with a few cc of aqua regia, diluted with water, and filtered. Phosphoric acid was determined in the filtrate by the official molybdate volumetric method. Although our results checked much better with those obtained by the Dyer modified method we were unable to obtain the ammonium phosphomolybdate precipitate in several of the treated extracts. It seems that the aqua regia treatment was not drastic enough, in some cases, to decompose some of the silicates that would tend to establish a competition for the adsorption of the phosphate ions in solution.

Our next procedure was then to evaporate the citric acid extracts to dryness with aqua regia and ignite the residue at low temperature to destroy the undecomposed organic matter and complete the dehydration and destruction of silicates. This treatment served as a basis for our recommended procedure (see pp. 288–289). Analytical results are expressed in Table II.

Analytical Results of Percent P_2O_5 by our Short Procedure

All analyses by both methods were performed in the same extraction. The letters A and B following a sample number represent duplicate extractions. All the analyses by Dyer's modified method and by our short procedure in samples 18, 20 and 23–27 inclusive, were made by the same chemist, F. A. Villamil. All other analyses by our short procedure were made by the senior author. The values in columns A and B represent percent P_2O_5 obtained respectively by the Dyer modified method and by our short procedure. The values of column A–B are obtained by subtracting the values of column B from those of A. The values D represent the mean deviations. The number of determinations $n = 45$. The value Z represents the ratio of the mean of columns (A–B) to the square root of the mean of the values D^2. The statistical interpretation of the results were obtained with values Z and n in the Student's table modified by Love (9).

TABLE II.

COMPARATIVE VALUES BY STUDENT'S METHOD OF PERCENT P_2O_5 AS DETERMINED BY THE DYER MODIFIED METHOD AND OUR SHORT PROCEDURE

No.	Dyer's A % P_2O_5	Short Procedure B % P_2O_5	A—B	D (A—B—.0003)	D^2
1A	.014	.016	—.002	—.0023	.00000529
1B	.014	.015	—.001	.0013	.00000169
2A	.010	.009	.001	.0007	.00000049
2B	.010	.009	.001	.0007	.00000049
3A	.003	.003	0	—.0003	.00000009
3B	.003	.003	0	—.0003	.00000009
4A	.007	.007	0	—.0003	.00000009
4B	.007	.007	0	—.0003	.00000009
5A	.013	.011	.002	.0017	.00000289
5B	.013	.010	.003	.0027	.00000729
6A	.005	.005	0	—.0003	.00000009
6B	.004	.006	—.002	—.0023	.00000529
7A	.002	.004	—.002	—.0023	.00000529
7B	.002	.005	—.003	—.0033	.00001089
8A	.017	.017	0	—.0003	.00000009
8B	.015	.017	—.002	—.0023	.00000529
9A	.006	.008	—.002	—.0023	.00000529
9B	.007	.006	.001	.0007	.00000049
10	.018	.017	.001	.0007	.00000049
11A	.036	.039	—.003	—.0033	.00001089
11B	.036	.039	—.003	—.0033	.00001089
12A	.146	.148	—.002	—.0023	.00000529
12B	.145	.155	—.010	—.0103	.00010609
13A	.023	.015	.008	.0077	.00005929
13B	.023	.014	.009	.0087	.00007569
14A	.013	.013	0	—.0003	.00000009
14B	.013	.013	0	—.0003	.00000009
15A	.019	.016	.003	.0027	.00000729
15B	.019	.016	.003	.0027	.00000729
16A	.023	.025	—.002	—.0023	.00000529
16B	.023	.025	—.002	—.0023	.00000529
17	.003	.002	.001	.0007	.00000049
18	.023	.020	.003	.0027	.00000729
19A	.052	.054	—.002	—.0023	.00000529
19B	.051	.053	—.002	—.0023	.00000529
20	.033	.038	—.005	—.0053	.00002809
21A	.019	.013	.006	.0057	.00003249
21B	.018	.013	.005	.0047	.00002209
22A	.005	.004	.001	.0007	.00000049
22B	.006	.004	.002	.0017	.00000289
23	.004	.001	.003	.0027	.00000729
24	.008	.005	.003	.0027	.00000729
25	.007	.005	.002	.0017	.00000289
26	.002	.001	.001	.0007	.00000049
27	.004	.002	.002	.0017	.00000289
Sum	.924	.908	.016		.00047045
Mean	.0205	.0202	.0003		.0000105

$$Z = \frac{.0003}{\sqrt{.0000105}} = .09$$

Odds: Below 3:1

When both methods are statistically compared, Z = .09 and the odds from the table (9) are found to be below 3:1. The odds indicate that there is no significant difference between the analytical results obtained by both methods.

That either method is as good as the other is corroborated by the excellent checks of the duplicates in different extractions.

Chances for personal analytical error are much less in the short

procedure since the work is greatly facilitated by the elimination of the cumbersome procedure required for precipitation of Fe, Al, Ti and P_2O_5 with NH_4OH in the Dyer modified method. The former method saves about 30 per cent of the time required by the latter.

Potash

Several modifications for the Dyer modified method were tried. Our results were unsatisfactory. We recommend the Dyer modified method with the following modification: Precipitate the lime together with the iro nand phosphoric acid. (See pp. 289–290).

Through the courtesy of Dr. W. W. G. Moir, agricultural technologist of the American Factors, Limited, Hawaii, and L. E. Davis, associate chemist of the Experiment Station of the Hawaiian Sugar Planters' Association, we obtained a reprint of Gow's (7) work on a rapid colorimetric method for the determination of potash. "This method consists essentially of precipitating potassium chloroplatinate by means of its insolubility in alcohol, dissolving the precipitate in water and developing a color by the addition of stannous chloride. The intensity of the yellow color thus produced is directly proportional to the amount of platinum present in the precipitate and hence to the amount of potash present."

SUMMARY

Research was undertaken with the purpose of shortening time without affecting accuracy of the Dyer modified method for the determination in soils, of phosphoric acid, lime and potash soluble in 1 per cent citric acid solution.

A short method is recommended for the lime determination based on the Chapman's method (4) for the precipitation of calcium oxalate in acid solutions (pH 3.9–4.2) in the presence of iron, aluminum, titanium, manganese, magnesium and phosphates. A short method is recommended for the phosphoric acid determination. Results are analyzed statistically by Student's method. Several of the colorimetric methods recommended for the phosphoric acid determination are also discussed.

Acknowledgments

The authors wish to express their acknowledgments to Mr. F. A. López Domínguez, Director of the Insular Experiment Station for valuable suggestions after reading the manuscript; to Mr. Bernardo

G. Capó, analytical chemist for the fertilizer control laboratory of the Department of Agriculture and Commerce and to Mr. Fernando Chardón, tobacco specialist of the Phytotecnics Division, Insular Experiment Station for valuable suggestions relative to the statistical interpretation of the chemical data, and to Dr. W. W. G. Moir, agricultural technologist of the American Factors, Limited, Hawaii and L. E. Davis, associate chemist of the Experiment Station of the Hawaiian Sugar Planters' Association for their courtesy in sending reprints of references (7) and (10), and for the proper citation of reference (3) which we requested after being unable to obtain the bulletin referred.

Bibliography

(1) **Arrhenius, O.** Fosfaat bepalling met de molybdeen-blauwmethode. (Phosphate determination with the molybdic-blue method). Archief Suikerindus Ned-Indie, **35**(2): 903–909. 1927.

(2) **Bell, Doisy & Briggs.** Determination of phosphorus in urine and blood. In John H. Yoe's Photometric Chemical Analysis, Vol. I, Colorimetry. Pp. 346–348. John Wiley & Sons, Inc., N. Y. 1928.

(3) **Burgess, P. S.** A study of the principal plantation soil types as found on the island of Hawaii. (Dyer's modified method.) H. S. P. A. Agr. & Chem. Bull. **45**: 94. 1917.

(4) **Chapman, H. D.** The precipitation of calcium oxalate in the presence of iron, aluminum, titanium, manganese, magnesium, and phosphates, with special reference to the determination of total soil calcium. Soil Sci. **26**: 479–486. 1928.

(5) **Deniges, G.** (An extremely sensitive reaction of phosphates and arsenates and its application.) Compt. Rend. **171**: 802–804. 1920.

(6) **Fiske, C. H., & Subbarow, Y.** The colorimetric determination of phosphorus, Jour. Biol. Chem. **66**: 375–400. 1925.

(7) **Gow, Paul L.** A rapid method for the determination of potash. The Hawaiian Planters' Rec. **35**: 401–409. 1931.

(8) **Lonstein, Ida.** Rapid colorimetric determination of phosphorous in soils and vegetation. Afric. Jour. of Sc. **23**: 188–195. 1926.

(9) **Love, H. H.** A modification of Student's table for use in interpreting experimental results. Jour. Amer. Soc. Agron. **16**: 68–73. 1924.

(10) **Ward Ritchie R.** The colorimetric determination of phosphorus in citric acid extracts of soils. Soil Sci. **35**: 85–97. 1933.

(11) **Warren, R. G., & Pugh, A. J.** The colorimetric determination of phosphoric acid in hydrochloric acid and citric extracts of soils. Jour. Agr. Sc. **20**: 532–540. 1930.

(12) **Yoe, John H.** Photometric chemical analysis. Vol. I. Colorimetry. (Beer's law) Chap. IV. Colorimeter calibration and correction curves, pp. 70–82; Chap. V. Errors in colorimetry p. 88. John Wiley & Sons, Inc., New York. 1928.

A VARIETY OF TOBACCO RESISTANT TO ORDINARY TOBACCO MOSAIC

By J. A. B. Nolla, John Simon Guggenheim Memorial Foundation Fellow, 1932–33, University of Wisconsin; and Arturo Roque, Assistant Phytopathogist, Insular Experiment Station, Puerto Rico.

The ordinary mosaic of tobacco affects a wide range of solanaceous hosts including most members of the genus Nicotiana. It is particularly severe on all varieties of *Nicotiana tabacum* L. heretofore studied in relation to the disease. In spite of the common occurrence of this virus disease on *N. tabacum* and the unusual opportunity afforded for the recognition of varietal or strain resistance to the disease, no such development has apparently been reported. Furthermore, the economic aspects of control of this malady are of such a nature that plant pathologists must have been on the lookout for cases of resistance to the disease for many years.

In the summer of 1929 the senior author visited the Cauca Valley of Columbia, South America. In these trips he observed several varieties of commercial tobacco, and his interest was curiously drawn to two varieties, seed of which was introduced into Puerto Rico. This seed obtained from Señor Carlos Rivera G., of Palmira, Department of Valle del Cauca, was presumably from the same stock of which plants were seen grown at the Santa Ana Farm of the Compañía Colombiana de Tabaco. The exact location is near the southeastern limits of the Department of Valle del Cauca.

The two varieties were grown in Puerto Rico, near Caguas, in 1929–1930 and it was during that year that the senior author observed the almost complete freedom from mosaic in one of the varieties, namely, the *Ambalema*. In a population of some six hundred plants, four individuals showed the disease as evidenced by a slower growth and by the characteristic symptoms on leaves. Unfortunately, no further studies were made with the susceptible plants. Selection of resistant plants was made from that progeny and crosses between these and a susceptible variety begun that year.

The senior author left Puerto Rico in the summer of 1930 and his studies were delayed for one year while doing graduate studies at Cornell University. He resumed this investigation in the fall of 1931.

In the meantime, the junior author, working at the Insular Experiment Station of Puerto Rico, discovered, independently, the resistance of this variety of tobacco to mosaic.

Both authors are now engaged in a study of the inheritance of resistance to mosaic. Our observations show that most plants of this variety inoculated with the virus of the ordinary tobacco mosaic do not exhibit any very marked symptoms. However, a clearing of the veins may be noticed in some individuals, while a smaller percentage exhibit chlorotic areas of a mild type, in the intervenal regions of the blade of the leaf.

Since the genetic nature of the resistance of this variety of tobacco was not well understood, an earlier note had seemed unwarranted. An explanation for the cases of susceptible individuals would have been desirable before publishing any note on resistance of the variety to mosaic. The senior author, in his annual report to the Chief Pathologist [See Cook (2)] in 1930, said concerning this variety:

. . . . "of the Colombian varieties one proved to be very promising", Page 97. Quite intentionally no mention is made of any specific quality.

Knowledge that the planting of this variety of tobacco is being extended in some places of the Island has prompted the writers to release this preliminary note. We wish to make it clear at this time that we are not responsible for the distribution among farmers of a variety of tobacco which has not yet been submitted to adequate selection and testing.

The senior author wishes to call attention to the fact that at the time the tobacco was collected in Colombia, no observations of resistance to mosaic were made. Our notes on prevalence of mosaic on the various farms rather showed that the variety was apparently susceptible. That we failed to detect freedom from symptoms of mosaic at that time may be explained in two ways. Either the mosaic of tobacco of that part of the continent is more virulent than the mosaic of Puerto Rico and the United States; or, as is most probable, the plants represented a very heterozygous population in which the susceptible individuals predominated. It is of interest, that in a small planting in Toro, Colombia, inspected on June 11th, no mosaic was observed even in plants a year old. No particular significance was attached to this observation at that time, and it was believed that such freedom from mosaic was the result of good cleaning of seed and careful handling of beds and seedlings.

The first illustrative record of this variety of tobacco, as far as the authors know, appeared in 1930 in a Puerto Rican publication (3). That picture was taken by the senior author near Toro, on June 11th, 1929. This town is located in the northern part of the Depart-

ment of Valle del Cauca. In this locality, however, the name given to the variety is "Pájaro Negro" (black bird). A plant of the first Puerto Rican grown tobacco of this variety is illustrated opposite page 97, Annual Report of the Insular Experiment Station of Puerto Rico, 1929–30. Bunker (1) publishes a figure of a "Variedad Colombiana Seleccionada y Aclimatada por el Especialista . . ." (Colombian variety selected and acclimated by the Specialist) . . ." Bunker obtained seed from our experimental plots of 1929–30 and, therefore, his plant must have been photographed the following season.

Doctor Carlos Durán Castro, formerly Director of the Agricultural Station at Palmira and now Chief of the Department of Agriculture in the Ministerio Nacional de Industrias at Bogotá, accompanied the senior author in most of his trips, being a source of constant encouragement. His courteousness on the one hand, and his devotion to our work, on the other, more than compensated for our efforts. He should have a considerable share of whatever credit may be reaped from the discovery of this important tobacco variety. The Hon. Carlos E. Chardón, formerly Commissioner of Agriculture of Puerto Rico and now Chancellor of the University of the Island, head of the Agricultural Mission to Colombia in the summer of 1929, also deserves our recognition for his valuable cooperation.

References Cited

(1) **Bunker, F. H.** Informe del Perito en Tabaco. In Rev. de Agr. Puerto Rico **26**: 177–186. 1931.

(2) **Cook, M. T.** Annual Report of the Division of botany and plant pathology for 1929–30. In Ann. Rpt. Insular Expt. Sta. Puerto Rico, 1929–30. 1930.

(3) **Nolla, J. A. B.** La industria tabacalera en el Departamento del Valle del Cauca. Puerto Rico Rev. de Agr. **25**: 85–96, fig. 1–13. 1930.

THE PINEAPPLE DISEASE OF SUGAR CANE IN PUERTO RICO

By Melville T. Cook, *Plant Pathologist*,
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This disease is caused by *Thielaviopsis paradoxa* (De Seynes) von Höhn and is widely distributed throughout the cane-growing parts of the world. This fungus was found first on pineapple in 1886 by De Seynes, who described it under the name of *Sporochisma paradoxum*. In 1892 Saccardo referred it to *Chalara paradoxa* (De Seynes) Sacc. In 1893 Went reported *Thielaviopsis ethaceticus* as the cause of a serious disease of sugar cane in Java. In 1904 von Höhnel reported that the organisms described by De Seynes and by Went were the same and made the combination *Thielaviopsis paradoxa* which has been very generally accepted from that time to the present. Dade (1928) (**4**) reported the finding of a *Ceratostomella* which he believed to be the perfect stage of the fungus which would become *Ceratostomella paradoxa.*

The fungus has been reported as attacking a large number of species of plants—sugar cane, pineapple, plantain, mango, coconut, date palm and many others. It has been reported from nearly all the countries in which sugar cane is grown. The geographical distribution according to the International Survey of the Disease of Sugar Cane (**3**) with a few additions, is as follows: Argentina, Australia, British Guiana, Ceylon, Colombia, Cuba, Dutch East Indies, Fiji, Formosa, Gold Coast, Hawaii, India, Jamaica, Java, Lesser Antilles, Madeira, Mauritius, Malaya, Mexico, Philippines, Portuguese East Africa, Puerto Rico, Reunion, Santo Domingo and Southern United States. It is reasonable to suppose that it occurs in all the other sugar-cane-growing countries. In Puerto Rico this fungus attacks the pineapples and is sometimes the cause of heavy losses in fruits and in young slips which have been planted for a short time. It attacks the coconuts and is sometimes the cause of the falling of a large number of young fruits and sometimes attacks the buds, causing a deformity of the young leaves and a slow dying of the trees. It attacks sugar cane, causes a rotting of seed cuttings and poor germinations, which will be described in this paper.

Went (1893) in the first record of this fungus attacking sugar cane stated that it was the cause of a serious disease. Some of the

pecially during the winter months. These outbreaks are expensive in proportion as they make replanting necessary. The first and most important treatment is a well-drained soil. In case of heavily infected soil it may be desirable to plant some other crop for a season or to use the Bordeaux treatment. This must be decided by the grower on basis of farm management and economics. In case the Bordeaux treatment is used, the cane should be treated very soon after cutting. If the seed cuttings become infected before treatment, the treatment is useless. When the grower has a few cuttings of a new variety, it is advisable to protect them by dipping the cut ends in tar or melted paraffin.

The Three-bud Seed Piece

The Puerto Rican practice is to use three-bud seed cuttings. This practice is no doubt the result of long years of experience and the writer believes that the *T. paradoxa* has been the deciding factor in favor of this method. Experimental work by the writer and others has demonstrated that there is a higher germination with three-bud cuttings than with cuttings of two buds or one bud. This is probably due to the length of the seed pieces rather than to the number of buds. In a long seed cutting the fungus has to travel a much longer distance than in short seed pieces and the buds have a better chance to germinate and become established before the fungus reaches them. The writer has found that when short seed cuttings for experimental studies are planted in unsterilized soil, it is advisable to dip the cut ends in melted paraffin or tar.

Other Causes of Poor Germination

Marasmius sacchari is one of the minor causes of poor germination in Puerto Rico. In one planting of one variety, this fungus killed 20 per cent of the buds.

Other causes of poor germination that have been reported from other countries are *Colletotrichum falcatum* and *Melanconium sacchari* in Louisiana, *Ceratostomella adiposum* in India and *Lasiodiplodia theobromae* in the Philippine Islands.

Bibliography

1. **Butler, E. J.** Fungus disease of sugar cane in Bengal. India Dept. Agr. Mem., Bot. Ser. **1**(3): 1–53. (1906).
2. **Cook, Melville T.** Coconut Fall. Journ. of the Dept. of Agri. of Puerto Rico. Vol. 8, No. 4, 3 pages. (1924.)

3. ———————. Rotting of Seed Cuttings in Porto Rico. Proc. of the Fourth Congress Int. Soc. Sugar Cane Tech. Bull. **36.** (1932.)

4. **Dade, H. A.** *Ceratostomella paradoxa,* the Perfect Stage of *Thielaviopsis paradoxa* (De Seynes). Brit. Mycol. Soc. Trans. **13**: 189–192. (1928.)

5. **Edgerton, C. W.** Some Sugar-Cane Diseases. La. Agri. Exp. Sta. Bull. **120.** (1910.)

6. **Fawcett, G. L.** Black Rot of Sugar Cane. Rev. Ind. Agri. Tucuman. **21**: 55–59. (1931.)

7. **Johnston, J. R.** Selection and Treatment of Cane Seed. Experiment Station of the Sugar Producers' Association of Puerto Rico. Bulletin No. **6** pp. 1–29. (1913.)

8. **Klotz, L. J. and H. S. Fawcett.** Black Scorch of the Date Palm caused by *Thielaviopsis.* Jour. Agri. Research. **44**: 155–166. (1932.)

WHITE SPOT OF PINEAPPLES

By Melville T. Cook, *Plant Pathologist*,
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This disease was reported from Puerto Rico by G. L. Fawcett of the Porto Rico Agricultural Experiment Station (Mayagüez) in 1908, who described it as follows:

"The pineapple has one conspicuous disease characterized by the appearance of white spots on the leaves. This is caused in many cases at least by the entrance of organisms through wounds such as the punctures made by sucking insects. At first the spots are small and brown. Gradually they enlarge, the epidermis sinks, the interior tissue is destroyed, and the white bleached appearance is taken on. It is in no sense a serious disease although common under excessively moist conditions."

Nowell (1922) says:

"A leaf-spot which is fairly common in the West Indies has been investigated by L. D. Larsen in Hawaii. It occurs on well-grown plants and its effect on their development is not usually appreciable. It has been shown to be due to the infection of insect and spine punctures, or other injuries, by the fungus Thielaviopsis. Infection and development depend on the prevalence of moist and cloudy weather or on the shading of the plants."

Larsen of Hawaii published a bulletin on diseases of pineapples in 1910 in which he described what appears to be the same disease as follows:

"The spots vary considerably, as regards size, shape and color. Many are large and white, and are noticeable from along distance, while others are small and inconspicuous. In typical mature spots there is a straw colored central area surrounded by a dark margin. Very often there is a dark center within the straw colored area, or dark blotches, due to the formation of the black macrospores within the tissue, may be scattered over it in an irregular manner. Sometimes long white arms extend beyond the dark border, and, again, the entire spot may be white or straw colored throughout. The internal tissue is soft and decayed at first, but this soon dries out, leaving the injured area dry and shrunken. The white or straw-colored area is not due simply to drying of the affected tissue, as is often the case with similar diseases, but comes on while the tissue is still quite firm, and long before it has begun to dry out. In early stages the spots may be olive brown in color and fairly regular in outline, or they may be white and irregular from the start. The size of the spots increases very rapidly, so that in two or three days what was a small brown spot will have become from two to six inches in length. Even twelve inches is not an unusual length."

Larsen believed these spots to be due to *Thielaviopsis paradoxa* which gained entrance to the plant through slight wounds. He said:

"The fungus, Thielaviopsis, which as we have seen causes Soft Rot of the pineaple fruit and Base Rot of the cuttings, is also responsible for a conspicuous disease of the leaves of this plant. It attacks the leaves through surface wounds made by insects and by the spines and sharp edges of neighboring leaves, and produces large discolorations or spots which often spread across the entire leaf and thereby kill all that part of the leaf which is above the spot. The spots may be found in almost any of our pineapple fields during the winter months, and at times become exceedingly numerous. They are most prevalent in the finest fields where the plants are green and vigorous, while in poor fields and on yellow plants they are more rare."

He conducted experimental work on which this conclusion was based and which demonstrated that the fungus could not gain entrance to the plant except through wounds. He also made very interesting studies on the influence of weather which he described as follows:

"In the infection experiments conducted it was found that when inoculations were made in the presence of bright sunlight, or if the leaves were exposed to sunny and dry weather conditions on the following day, but very few of the inoculations would take. It was therefore necessary when inoculating leaves under such conditions to cover the wounds with grafting wax or paraffin. When the plants were shaded or when cloudy weather existed after inoculation, infection took place very readily without such protection. Direct sunlight prevents infection; first by drying out the wounds, and secondly, by killing the spores of the fungus. In the experiment mentioned on page 15 it was found that the most resistant form of Thielaviopsis spores are killed in a few hours when exposed to direct sunlight. With this in view it is evident why the spots are scarcely known during the dry summer season and yet become very numerous in the winter months.

"The size of the spots is also governed largely by weather conditions. Sunlight and dry weather, after infection has taken place, tend to limit the size while moist and cloudy weather has the opposite effect. In our infection experiments when the plants were well shaded the entire leaf would often become involved.

"It was furthermore noted that the typical white condition would make its appearance only on leaves that were exposed to sunlight. When inoculated plants were kept in the shade the spots would invariably be brown in color and very regular in outline, whereas when exposed to sunlight the white and irregular patches would appear. They appeared, however, in a sporadic manner, occurring on one leaf here and another there, while other leaves inoculated at the same time and equally exposed would show none of it. It was at first thought that this white appearance was a distinct trouble due to some cause other than Thielaviopsis, but judging from the results of our infection experiments such does not appear to be the case."

A very pronounced outbreak of this disease in the vicinity of Co-

rozal was called to the attention of the writer in August of 1932. These plantings were at an elevation of about 350 or 375 feet and on the boundary line between limestone soils of the coastal plain and the volcanic acid soils.

There had been heavy rainfall and the disease appeared in such abundance that the grower became very much alarmed. The fungus (*Thielaviopsis paradoxa*), which is well known as a parasite on a number of species of plants in Puerto Rico, had been reported previously to the writer as the cause of a very serious fruit rot in this locality. The symptoms, the weather conditions and the presence of the fungus, conformed with Larsen's Hawaiian report of 1910.

A large amount of the diseased leaves were collected and taken to the laboratory for study. A study of free-hand sections did not show a fungus. A large number of cultures were made but the fungus did not develop in any of them. *Thielaviopsis paradoxa* grows readily in culture and the writer has isolated it many times from decaying pineapple fruits, slips, sugar cane, coconuts and other plants, using the same medium as was used at this time. Material was then prepared for paraffing sectioning and staining but the results were again negative. It was impossible to conduct inoculation work at the Experiment Station, owing to lack of plants.

When the rainfall was reduced and bright sunshine prevailed for a few days, no new spots were formed. This was followed by another period of rainy weather and another outbreak of the disease. Therefore, it appears from these studies that these spots may be the results of weather conditions without the influence of any other agency. Field studies by the writer did not indicate that a puncture by a spine, insect or any other agency was necessary for the formation of these spots.

PATHO-ANATOMY OF ROOTS ATTACKED BY NEMATODES

By Melville T. Cook, *Plant Pathologist,*
Insular Experiment Station, Río Piedras, P. R.

Very little study has been made in America of the anatomy of plants attacked by nematodes since the publication of Atkinson's "Nematode Root-Galls" (1) in 1889. During the past few years the writer has devoted some attention to this subject and the data on the dicotyledonous plants will be presented in this paper. The plants used in these studies were tomato, tobacco and ornamental Coleus. The results were the same in all cases and it would have been impossible to distinguish them except for the labels. The galls were caused by *Heterodera marioni* (Cornu) Goodey (= *Heterodera radicicola* Greeff).

The nematodes attack the very young roots. The writer is of the opinion that they rarely, if ever, attack roots more than one millimeter in diameter. Young roots contain a large amount of tissue that is capable of division when stimulated. This includes the cambium, cortex and medullary rays. The parasites penetrate into the cortex and the rays where they stimulate an excessive growth. The writer is of the opinion that they rarely if ever penetrate into the fibrous or tracheary tissue.

All cells that retain the power of division are stimulated by the parasites. This stimulation results in the formation of a large number of very small cells in close contact with the parasite while those a distance are much larger (Figs. 3 & 5b). When the nematode attains full size the stimulation appears to cease and the cells become larger (Fig. 4b). The parasite does not appear to stimulate cell division or growth in the fibrous or tracheary tissues, but does push them out of the normal position. The parasite also causes the formation of tracheary tissues from and in the parenchyma tissue (Fig. 1b.)

Nematodes in the axis cylinder (Fig. 2) penetrated through the parenchyma cells and not through the fibrous or tracheary cells.

The writer is inclined to believe that galls may be reinfected many times and that reinfection accounts for the larger galls. The tissues of a gall are highly meristematic as a result of stimulation by previous infections and are very favorable for reinfections. The tissues of the large galls are in such a state of confusion resulting from the large number of parasites and the reinfections that a histological

study is of little or no value. Any satisfactory study of the development of these galls should begin with the very young galls.

Atkinson's studies evidently were made on the galls that were advanced to a point where it was impossible to determine the incipient characters, but his description and discussion are very interesting. He said:

"The worms locate preparatory to passing into the cystic state at various depths in the tissues of the root. They are not confined to any particular tissue element or system but locate in the vascular tissue of the central cylinder, the cambium, parenchyma or even in the bark so that the body of the mature female cyst is frequently only protected by a thin layer of the dead peripheral tissue, or sometimes is even exposed. They seem to flourish better, however in or near the softer tissues of the root. It is a very common thing to find dead undeveloped female cysts, the majority of which I have always found in the woody tissue of the central cylinder. Possibly surrounded as they are by the harder, more compact tissue there is less certainty of the male reaching them for fertilization. This, however, is only a suggestion. I have not demonstrated it. All of the tissue elements in the diseased roots undergo hypertrophy, while some of them are subject to special changes in form as well as direction of growth.

"The parenchyma cells which normally have their tangential diameter greater than the radial are so changed that the radial diameter is the greater. This change in form of the parenchyma cells seems to obtain in nearly all of the parenchyma in the gall whether very near a cyst or distant from it. The increase in number of the wood and vascular cells of the central cylinder takes place though the cyst may not be located in or very near it. In such cases the fibres and ducts have their normal longitudinal direction. But if a cyst is located in or very near the central cylinder the ducts are turned in their direction of growth perpendicular to the axis of the root, bent around the cyst and then converge on the peripheral side, when, left, without any controlling influence over their direction of growth they often perform very curious evolutions through the parenchymatous tissue in all directions."

My results are not altogether in harmony with those given by Atkinson. Some of the nematodes stop in the cortex of the roots while others penetrate to the center of the axis cylinder which makes it necessary to consider the action of the nematodes on these two sets of tissues.

The writer agrees with Atkinson in the statement that the nematodes are found in all the tissues of the galls but as a result of studies on very young galls, the writer is of the opinion that the galls originate in the very young roots and at a period when most of the cells have retained the power of division. The writer is very doubtful if the parasites ever penetrate into the fibrous and tracheary tissues. The galls appear to originate in the young cortical tissues. As a result of the irritation by the parasites the fibrous and tracheary

tissues in the axis cylinder become distorted and sometimes displaced; new fibrous and tracheary tissues are formed in the cortical regions.

The size and shape of the galls depends primarily on the number of parasites in the roots and to some extent on their position in the roots and the age of the roots at time of infection. The writer is of the opinion that roots of more than one millimeter are rarely if ever infested.

The writer disagrees with Atkinson in his statement that "all the tissue elements in the diseased roots undergo hypertrophy". There is no hypertrophy of the tracheary tissue but new tracheary tissue is formed from the cortex. The writer also disagrees with Atkinson's statement that "the parenchyma cells which normally have their tangential diameter greater than the radial are so changed that the radial diameter is the greater". This statement is sometimes true especially in the very large galls which contain a large number of the parasites.

There is an enlargement of the roots due primarily to the excessive division and growth of the cells of the cortex. In most cases these cells are only slightly modified. Those next to the nematodes are somewhat smaller than normal. The larger cells may be slightly shorter (i. e. isodiametric) than in normal roots.

The cells in the axis cylinder do not increase in number but are pushed out of place by the growing nematodes.

There is a tendency for an increase in the amount of tracheary cells at the expense of the fibrous cells. Sometimes the axis cylinder is supplanted by the nematodes.

One part of an axis cylinder may be distorted and the other part normal.

The final result of the stimulation by the parasite is great masses of cells, the formation of new fibrous and tracheary tissues which are intermingled in the parenchyma in an irregular manner.

Atkinson compared the nematode galls with those caused by *Plasmodiophora brassicae* as follows:

"But if we take a thin transverse section of an enlarged root of each and compare them all resemblance vanishes. In a cross section of 'club-foot' the first thing to attract attention is the great number of yellowish plasmodia, or else the spore masses within large cells, distributed all through the tissues. If the section is from an enlargement of a lateral root, unless very large, there will be little else to attract the attention when compared with a healthy root unless it be a slight enlargement of some of the other cells. The general char-

acter of the root structure is but little changed. The tracheral tissue of the axis cylinder, but little attacked is arranged in the same stellate form which we find it in a healthy root. The ducts, even when immediately in contact with cells containing plasmodia, are not turned from their longitudinal direction, or if so only slightly. The cells are not elongated and curved around the enlarged cells containing the plasmodium, but resemble the normal arrangement of small cells around a large one. Nor is the radial diameter of the parenchymatous cells proportionately increased, but if the cells are enlarged it is usually a proportionate or nearly symetrical enlargement.''

The above comparison is very satisfactory for a comparison of sections of galls well advanced in their development. However, comparisons of the old galls are of very little value. Comparisons of young galls would no doubt give us some information concerning the developmental history. The writer has not had an opportunity of studying the *Plasmodiophora brassicae* galls but judging from the description of the histology by Lutman (**2**) and Kunkel, (**4**) they are much more simple in structure than the galls caused by nematodes. Lutman said:

''The difference between the cross-sections from a healthy root and those from a diseased one lies in the presence in the greatly hypertrophied cells of the cortical parenchyma of an opaque, colorless, finely granular plasma. The cortex is greatly increased in size and this enlargement is due to an increase in the number of the cells as well as to hypertrophy of the individuals. The vessels are often bent and shoved out of their proper position in diseased roots, but, as in normal ones, only contain air. The hypertrophied cells become filled in the older roots with small round spores of the organism to which Woronin gave the name of *Plasmodiophora Brassicae.*

Kunkel does not give us the history of the development of the very young galls caused by *P. brassicae,* but he said:

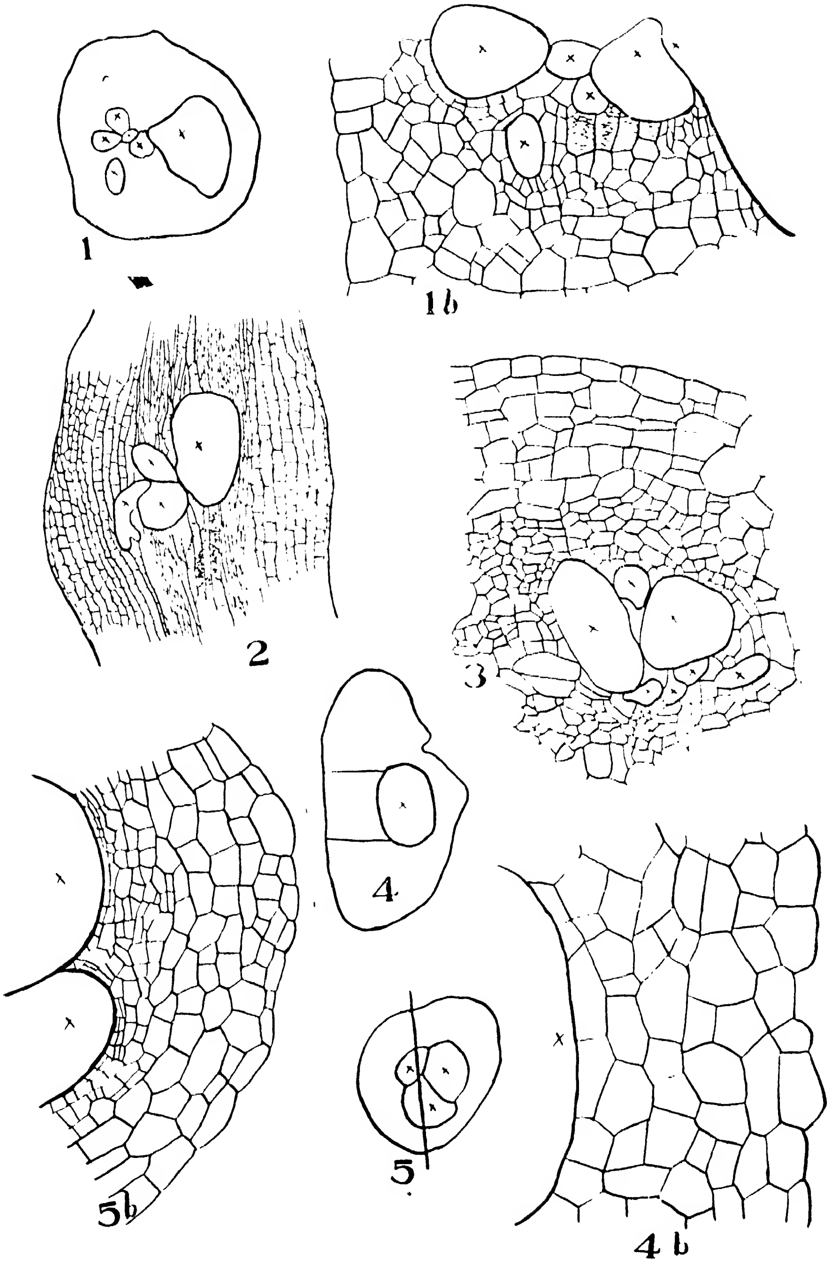
''Many of the host cells are very much enlarged, especially near the point of original infection. During the sixteenth and seventeenth days the parasite spreads still farther into the healthy tissues of the stem. It has not penetrated very much deeper, however, and does not seem to be able to attack the woody parts, at least to any very considerably extent.

''While the thickening of the cortex is accomplished more by cell growth than by cell multiplication, the swelling in the cambium region is brought about largely by an increase in the number of cells.''

He also stated that the cambium contributed to the enlargement, that the cortex grew, that the cortical cells were enlarged while those of the cambial region were small and that the parasite penetrated the rays and stimulated the cells so that the bundles were forced apart.

It appears to the writer that the galls resulting from nematodes are much more complex than the galls caused by *P. brassicae.*

PLATE XXIII



Summary

1. Root galls caused by nematodes (*Heterodera marioni*) originate as a result of attacks on meristematic tissues of very young roots.

2. The parasite may locate in the cambium or cortex or penetrate in the medullary rays.

3. There is no evidence that the parasite can attack fully formed fibrous and tracheary tissues or that it can stimulate their growth, but it can push them out of place.

4. The cambium, cortex and medullary rays are stimulated to excessive cell division and tracheary tissue is formed in the cortex.

5. The cells next to the parasites during the period of gall formation are very small as a result of excessive cell division while the more remote cells are much larger.

Literature

1. **Atkinson, Geo. F.** Nematode Galls. Alabama Agri. Exp. Station. Bulletin No. 9. 1889.
2. **Lutman, B. F.** Studies on Club-Root. Vermont Agricultural Experiment Station. Bulletin No. 175. 1913.
3. **Chupp, Charles.** Studies on Club-Root of Cruciferous Plants. New York (Cornell) Agri. Exp. Station. Bulletin 387. 1917.
4. **Kunkel, L. O.** Tissue Invasion by Plasmodiophora brassicae. Journ. Agri. Research **14**: 543–575. 1918.

Explanation of Plate

Fig. 1. Cross section of small root showing location of nematodes.

Fig. 1 *b*. Part of same showing the effect on the cells.

Fig. 2. Longitudinal section of small root showing location of nematodes.

Fig. 3. Cross section of a root showing location of nematodes. Note there is no tracheary tissue.

Fig. 4. Cross section of a root. Note there is no tracheary tissue.

Fig. 4 *b*. Part of same. Note the enlarged parenchyma cells.

Fig. 5. Cross section of small root. Note there is no tracheary tissue.

Fig. 5 *b*. Part of same. Note the parenchyma cells.